

Kennedy/Jenks Consultants

South Tacoma Field
Superfund Site
Tacoma, WA

Phase I Soil Investigation Report



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Draft Report

PHASE I SOIL INVESTIGATION REPORT

**SOUTH TACOMA FIELD
SUPERFUND SITE
REMEDIAL INVESTIGATION/FEASIBILITY STUDY**

DRAFT

Prepared for

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EXECUTIVE SUMMARY

This report describes findings associated with the Phase I Soil Investigation performed as part of the South Tacoma Field (STF) Remedial Investigation/Feasibility Study (RI/FS). The Phase I Soil Investigation was performed as outlined in the Final Work Plan (ICF 1990b), which establishes the level of effort required by the U.S. Environmental Protection Agency (EPA) to complete the RI/FS.

PURPOSE AND INVESTIGATIVE ACTIONS

The two principal objectives of the Phase I Soil Investigation are to:

- Characterize the types and concentration distributions of target chemicals of concern detected in onsite surface soil.
- Acquire chemical concentration data, in conjunction with data from the Phase I Groundwater Investigation, geophysical survey, and soil gas survey to develop the Phase II Soil Investigation Field Sampling and Analysis Plan Amendment.

Based on historical use and previous investigations conducted at the site, a sampling grid system was established over the STF site with three different sampling densities corresponding to high-, medium-, and low-perceived risk areas. The STF site was divided into six sampling units based on the perceived risk (see Figure SS-5 in Section 2.0). In the two high-perceived risk sampling units, a composite of five grab samples was collected from each grid. Grab samples were collected at the nodes of the sampling grids from all other areas.

The following tasks were completed during the Phase I Soil Investigation:

- Collected 11 surface soil background samples from 10 offsite locations within the South Tacoma Channel for chemical analyses.
- Collected 622 surface soil samples from within the STF site for chemical analyses.
- Collected 40 surface soil samples from within the STF site for characterization of physical soil properties.
- Collected 32 subsurface soil samples from 8 dry wells (DW) located on Tacoma City Light property for chemical analyses.
- Collected 27 subsurface soil samples from 5 borings located on Pioneer Builders Supply property (a portion of the BNR Railyard) for chemical analyses.

Approximately 20 percent of all surface soil samples were analyzed for boron and cyanide, and for the full suite of Target Compound List (TCL) parameters as described in EPA's Contract Laboratory Program (EPA 1988b; 1990a,b). The remaining surface soil samples were analyzed for a subset of the full suite of TCL parameters: metals, polynuclear aromatic hydrocarbons (PAHs), and boron. Samples collected from Tacoma City Light property were analyzed for the full suite of TCL parameters. All samples collected from Pioneer Builders Supply property were analyzed for PAHs, semivolatile organic compounds, and volatile organic compounds (VOCs). Eight randomly selected samples from Pioneer Builders Supply were analyzed for the full suite of TCL parameters, including boron.

INORGANIC ANALYTICAL RESULTS

Background (Offsite)

All TCL inorganics were detected in most samples collected from offsite locations and most detected concentrations were approximately equivalent to average inorganic soil concentrations (Lindsay 1979). Exceptions included cadmium, beryllium, potassium, and sodium. The detected mean background concentration for cadmium was approximately seven times higher than the average soil concentration for cadmium. The mean background concentrations for beryllium, potassium, and sodium were significantly (1 order of magnitude or more) lower than the average soil concentrations for these same constituents.

STF (Onsite)

Concentrations of most inorganics in samples collected from the STF site exhibited elevated concentrations compared to the 95 percent upper confidence level (95% UCL) of samples collected from offsite locations. Particularly elevated concentrations of inorganics were detected from the BNR Dismantling Yard, the BNR Railyard, and Amsted, where historical activities and previous investigations indicated that high concentrations of inorganic hazardous substances were likely to be detected. Lower concentrations of inorganics were detected in samples collected from the Former Swamp/Lakebed, the Airport, and Tacoma Industrial Properties (TIP) sampling units.

Tacoma City Light

Most TCL inorganics were detected in samples collected from Tacoma City Light dry wells. The subsurface maximum inorganic concentrations were significantly less (typically by 1-2 orders of magnitude) than the maximum inorganic concentra-

tions detected in onsite surface soil samples. Maximum detected concentrations of inorganics in the subsurface soil were also typically 1 order of magnitude or less than the area surface soil background concentrations (95% UCL), except for chromium, copper, and sodium.

Pioneer Builders Supply

Generally, the inorganics detected in samples collected from Pioneer Builders Supply did not vary significantly with depth or among borings. Concentrations of inorganics in subsurface soil at Pioneer Builders Supply were below or only slightly above the area background surface soil concentrations (95% UCL).

ORGANIC ANALYTICAL RESULTS

Background (Offsite)

Most samples collected from offsite locations exhibited concentrations of PAHs, including PAHs considered to be probable human carcinogens (EPA 1991). Only three semivolatile organic compounds [not including PAH compounds or tentatively identified compounds (TICs)] were detected in background samples. Of the VOCs, methylene chloride was detected in every sample (and in the laboratory blanks) and benzene was detected in one sample. Only one pesticide and one polychlorinated biphenyl (PCB) compound each were detected in two separate background samples.

STF (Onsite)

Samples collected from the STF site exhibited elevated concentrations of all TCL PAH compounds compared to the 95% UCL of samples collected from offsite locations. Generally, the highest concentrations of PAHs were detected in samples

collected from the eastern and northern portions of the BNR Dismantling Yard, the eastern edge in the north-central portion and in the southern portion of the BNR Railyard, the northern portion of Amsted, the central portion and along the eastern border (adjacent to Amsted and TIP) of the Former Swamp/Lakebed, the northern and northeastern portions of the Airport, and the northwestern portion of TIP.

Semivolatile organic compounds were detected in samples collected throughout the BNR Dismantling Yard and in scattered locations in the Former Swamp/Lakebed. Semivolatile organic compounds were also detected in samples collected from scattered locations throughout the BNR Railyard. Elevated concentrations were typically detected in samples collected from the central and southern portions of the BNR Railyard. Semivolatiles (not including TICs) were detected in samples collected from scattered locations in the other sampling units (except from Amsted, where no semivolatile organic compounds were detected).

VOCs (except for acetone and methylene chloride) were detected primarily in samples collected from the central and western portions of the BNR Dismantling Yard and the central section of the BNR Railyard. VOCs were detected in samples collected from scattered locations in the other sampling units.

Six pesticides were detected in five samples collected from scattered locations in the STF site. PCBs were only detected in samples collected from the BNR Dismantling Yard and the BNR Railyard. The highest PCB concentrations were detected in samples collected from the northern end of the BNR Railyard.

Total dioxins and furans were detected at low concentrations (less than 1 $\mu\text{g/Kg}$) in samples collected from the BNR Dismantling Yard and the BNR Railyard.

Geotechnical test results were generally indicative of a sandy soil mixed with gravel.

Tacoma City Light

One or more PAH compounds were detected in each of the 32 subsurface soil samples collected from Tacoma City Light dry wells. PAH concentrations typically decreased with overall depth. Generally, total PAH concentrations in samples collected from the shallowest locations were 1-2 orders of magnitude greater than samples collected from the deepest locations. Samples collected from DW-26 exhibited the highest detected concentrations of PAHs.

Twelve semivolatile organic compounds (not including PAHs or TICs) were detected in samples collected from Tacoma City Light dry wells. DW-10, DW-15, and DW-19 exhibited the fewest number of detected semivolatile organic compounds. DW-26 typically exhibited the highest number and highest concentrations of semivolatile organic compounds. In general, for semivolatile organic compounds detected in more than one sample from a dry well, concentrations decreased with depth.

Although VOCs were detected in samples collected from all dry wells, no consistent trends in the vertical distribution were identified. Only one pesticide (aldrin) was detected in samples collected from DW-13. PCBs were detected in 10 samples collected from five dry wells (DW-18, DW-19, DW-20, DW-21, and DW-26) with a maximum detected concentration of 840 mg/kg.

Pioneer Builders Supply

PAHs were detected in 14 of the 27 subsurface soil samples collected from borings advanced at Pioneer Builders Supply. Probable carcinogenic PAHs were detected in only four of the samples collected with a maximum concentration of 0.20 mg/kg. In instances where PAH concentrations were detected in samples collected at two or more depths in a boring, concentrations usually decreased with increasing depth.

Eight semivolatile organic compounds were detected in samples collected at Pioneer Builders Supply. 1,2,4-Trichlorobenzene and 2-methylnaphthalene were the most frequently detected compounds. In many boring locations, semivolatile organic compound concentrations increased with increasing depth, when comparing samples collected from two adjacent intervals.

Five VOCs, including methylene chloride and acetone, were detected in the subsurface soil samples collected from Pioneer Builders Supply. Methylene chloride and acetone were detected in most laboratory blanks (i.e., indicative of laboratory contamination) and probably do not represent actual soil concentrations. The highest concentrations of VOCs were detected in samples collected from boring B-3, which was located inside the tank excavation (see Figure SS-8 in Section 2.0).

Pesticides were not detected in samples collected from Pioneer Builders Supply. PCBs were detected in three of the subsurface soil samples collected from the deepest sampling intervals from two borings (B-2 and B-3). Both borings were located within the excavation area.

CONCLUSIONS

- Chemicals of concern, particularly inorganics and PAHs, were detected in surface soil at the STF site.
- Industrial activities that have occurred at some locations at the site probably contributed to the elevated concentrations of chemicals of concern detected in soil samples collected onsite.
- Because semivolatile organic compounds and VOCs were analyzed in only 20 percent of the collected surface soil samples, distribution trends are difficult to identify. The presence of methylene chloride, acetone, and toluene are apparently attributable to laboratory contamination.

- Because all surface soil samples were not analyzed for PCBs, it was not possible to define the spatial extent of elevated PCB concentrations along the southern edge of the BNR Dismantling Yard and the northern end of the BNR Railyard.
- Dioxins and furans were detected in selected surface soil samples at concentrations that were similar for industrial sites (Creaser et al. 1990).
- Concentrations of inorganics in Tacoma City Light dry wells were not uniform with depth [i.e., concentrations would often decrease then increase (or vice versa) over a relatively short vertical sampling interval].
- Detected concentrations of PAHs in samples collected from Tacoma City Light dry wells and some semivolatile organic compounds and VOCs may have resulted from the incomplete combustion of fossil fuels and leaching of wood treatment products.
- PCBs detected in samples collected from Tacoma City Light dry wells may have originated from historical handling and storage of transformers containing PCB-bearing dielectric fluids. VOCs detected in subsurface soil samples collected from the dry wells may have been from solvents used in maintenance activities. Semivolatile organic compounds may have been contained in plastic materials used at the utility.
- Most chemicals of concern detected in subsurface soil samples collected from Pioneer Builders Supply were present at low concentrations and with limited vertical and horizontal distributions.
- Low concentrations of the semivolatile organic compounds and VOCs in subsurface soil samples collected from Pioneer Builders Supply are probably due to releases from the underground tanks located at the site. The sources of PCBs and PAHs detected in subsurface samples are unknown.

1.0 INTRODUCTION

This report describes findings associated with the Phase I Soil Investigation performed as part of the South Tacoma Field (STF) Remedial Investigation. The STF site, located in Tacoma, Washington, is a former industrial property approximately 300 acres in size. The site is in western Washington State (see Figure G-1) in the southwestern section of the City of Tacoma (see Figure G-2). Currently, the STF site is largely vacant with some remnant structures and recently constructed industrial buildings.

On 23 November 1981, the U.S. Environmental Protection Agency (EPA) published an "interim priority list" of 115 top priority hazardous waste sites targeted for action under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The STF site was listed on the initial National Priorities List (NPL) as a portion of the Commencement Bay-South Tacoma Channel site. On 30 December 1982, EPA proposed modifications to the NPL. The list increased to 418 sites and the Commencement Bay-South Tacoma Channel site was divided into four separate sites: the Deepwater, the Nearshore, the Tideflats Industrial, and the South Tacoma Channel. On 8 September 1983 (48 FR 40658), the South Tacoma Channel site was further divided into separate operable units with unique NPL site numbers (e.g., STF, Tacoma Well 12-A, Tacoma Landfill) (Bennett, D., 3 January 1992, personal communication).

On 12 October 1990, EPA and the potentially responsible parties (PRPs) signed an Administrative Order on Consent (Consent Order) for the STF site. The Consent Order, among other requirements, directed that a remedial investigation be conducted to determine the nature and extent of environmental contamination by hazardous substances at the STF site.



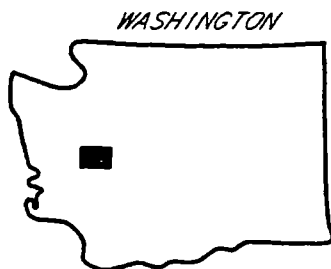
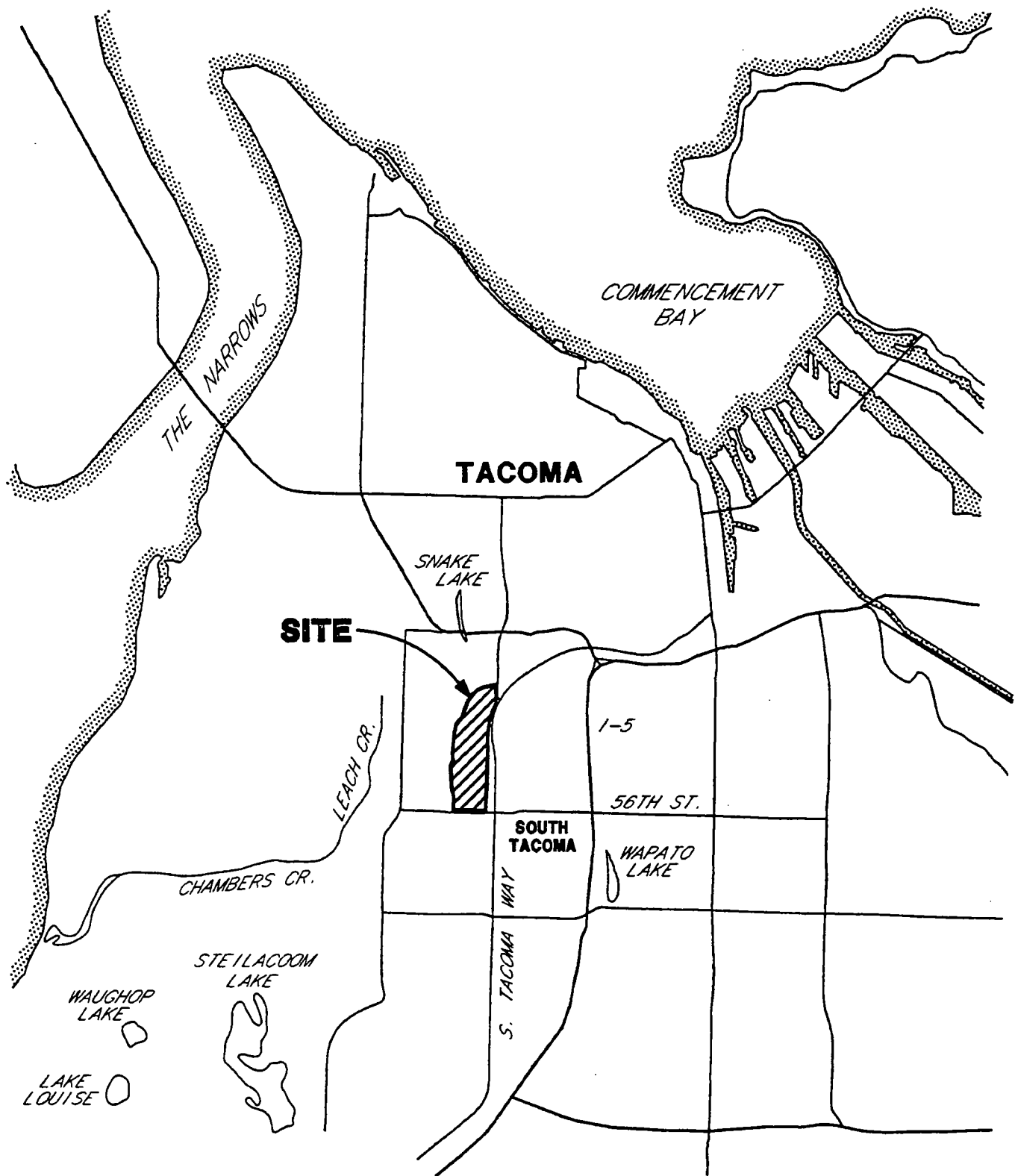
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**SOUTH TACOMA FIELD
TACOMA, WASHINGTON**

REGIONAL MAP

916055.02/P1SK092

FIGURE G-1



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SOUTH TACOMA FIELD
TACOMA, WA

SITE LOCATION MAP

916055.06/P1SK046

FIGURE G-2

The Consent Order cites the Final Work Plan, which establishes the level of effort required by EPA to complete a Remedial Investigation/Feasibility Study (RI/FS) at the STF site. The Final Work Plan was prepared for EPA by ICF Technology, Inc. (ICF 1990b). Kennedy/Jenks Consultants was retained by the PRPs to conduct the RI/FS in accordance with the Final Work Plan, Revision 1, dated September 1990 (ICF 1990b).

The STF RI is composed of discrete investigations of potential contamination associated with several media, including surface soil and subsurface soil, ground-water, surface water/sediment, air, and blackberries. A soil gas survey, geophysical survey, and wetland delineation and endangered plant species survey are also discrete components of the STF RI. Results of each of these investigations will be presented separately in draft and final reports and then synthesized for the RI report. This document presents the findings of the STF Phase I Soil Investigation.

1.1 PURPOSE OF INVESTIGATION

The two principal objectives of the Phase I Soil Investigation are to:

- Characterize the types and concentration distributions of target chemicals of concern detected in onsite surface soil.
- Acquire chemical concentration data, in conjunction with data from the Phase I groundwater investigation, geophysical survey, and soil gas survey, to develop the Phase II Soil Investigation Field Sampling and Analysis Plan Amendment.

The Phase I Soil Investigation consisted of extensive surface sampling throughout the STF site and preliminary subsurface sampling, and subsequent laboratory analyses of these samples as detailed in the STF Field Sampling and Analysis Plan

(FSAP) and the STF Quality Assurance Project Plan (QAPjP) (Kennedy/Jenks/Chilton 1991b,c). The following tasks were completed during the Phase I Soil Investigation:

- Established a sampling grid system over the STF site with three different sampling densities corresponding to high-, medium-, and low-perceived risk areas, based on historical site use and previous investigations.
- Collected 11 surface soil background samples from 10 offsite locations within the South Tacoma Channel for chemical analyses.
- Collected 622 surface soil samples from within the STF site for chemical analyses.
- Collected 40 surface soil samples from within the STF site for characterization of physical soil properties.
- Collected 32 subsurface soil samples from 8 dry wells located on Tacoma City Light property for chemical analyses.
- Collected 27 subsurface soil samples from 5 borings located on Pioneer Builders Supply property for chemical analyses.

1.2 REPORT ORGANIZATION

The remaining sections of this Phase I Soil Investigation Report are described below:

- Section 1.0 concludes with a description of the site geology and soil types, and a summary of the site history, current land use, and previous surface soil investigative results.

- Section 2.0 summarizes investigative methods, including a description of the sampling rationale and methods for the surface and subsurface soil investigations. Sample locations, collection procedures, laboratory analytical methods, and decontamination procedures are discussed.
- Section 3.0 summarizes the quality assurance (QA) program for field and laboratory data, and includes a discussion of the data validation process and the statistical analyses of laboratory analytical results. A summary of the analytical results of the field QA/QC (duplicates, blanks) samples is also presented. In addition, an explanation of database printouts of analytical data is presented.
- Section 4.0 describes the investigative results (analytical data) for the samples collected from offsite background locations and the STF site surface soil sampling locations. Analytical data for the preliminary subsurface soil investigations at Tacoma City Light and Pioneer Builders Supply are also included.
- Section 5.0 presents the summary and conclusions based on results reported in Section 4.0.
- Section 6.0 includes references for documents cited or used in preparation of this report.

In addition, the Phase I Soil Investigation Report includes the following appendices:

- Appendix SS-A (Boring Logs), which is bound at the end of this report.
- The Phase I Soil Investigation Reference Appendix (Reference Appendix), which is bound separately, contains 11x17-inch Chemical Distribution Figures and Chemical Concentration Maps.

- The Phase I Soil Investigation Data Appendix (Data Appendix), which is also bound separately, contains the analytical results for this investigation.

1.3 SITE GEOLOGY AND SOIL

This subsection describes the general geological characteristics of the area and provides a description of soil types at the STF site.

1.3.1 Geology

The STF site lies within the South Tacoma Channel (Channel), a geomorphic feature produced during the Vashon Glaciation. The Vashon Glaciation of the Puget Lowland occurred between 13,000 and 20,000 years before present. The Channel acted as a drainage course for outflow from glacial Lake Puyallup during the retreat of the Puget lobe of the glacier.

The Vashon Drift is the only geologic formation exposed at the surface in the site. The Vashon Drift consists of many members, including the Steilacoom gravel, an unnamed till unit, and the Esperance or Colvos Sand (Noble 1990). The Vashon Drift is widely exposed throughout the Puget Lowland.

The uppermost unit at the site is the Colvos Sand member of the Vashon Drift. This member consists mainly of poorly graded (well-sorted) sands containing minor amounts of gravel and silt. The Colvos Sand represents advance outwash sands and gravels that were deposited from meltwater streams along the leading edge of the glacier during its southward advance. Previous studies [Brown and Caldwell 1985; Remedial Technologies (ReTec) 1987; and ICF 1990a] indicate that the uppermost exposed unit in the Channel is the Steilacoom gravel member of the Vashon Drift. However, stratigraphic information gathered from the well installation

portion of the groundwater investigation (Kennedy/Jenks Consultants 1991a, 1992 in press) did not reveal the presence of Steilacoom gravels in the Channel.

Other units overlying the Colvos Sand were encountered locally during well installation at the site. These units included fill material and debris of anthropogenic origin, and peat and organic material near bodies of surface water.

1.3.2 Soil Associations

The U.S. Department of Agriculture Soil Conservation Survey has surveyed soils in the vicinity of the STF site (USDA 1979). Although the STF site was not included in the survey, USDA mapped soils to the west and south of the STF site. Information from the survey can provide an indication of the soil types that might be found at the site.

Soils located west of Orchard Street (approximately 0.5 miles west of the STF site) belong to the Alderwood-Everett association. This association is characterized by nearly level to rolling, moderately well-drained and somewhat excessively drained soils that formed in glacial till and glacial outwash (USDA 1979).

The Spanaway association is predominant south of South 74th Street (approximately 1.25 miles south of the STF site). Reportedly, this association is representative of STF site soil (ICF 1990a). The Spanaway association consists primarily (67 percent) of Spanaway series soils, which are somewhat excessively drained and gravelly. Spanaway series soils formed in glacial outwash that was mixed with volcanic ash. Surface soils are characterized as gravelly sandy loam in the upper 18 inches underlain by a gravelly sand from 18 to 60 inches.

According to ICF (1990a), the original topsoil at the STF site typically consists of dark brown to black sand with silt and organic matter. The underlying layer usually

consists of sandy materials and gravel. The sandy material generally conforms with the description of soils found in the Spanaway series.

Most, if not all, of the original site soils are covered by varying thicknesses of fill material (ICF 1990a). The fill material increases in depth from less than 1 foot in the eastern portion of the site to approximately 15 feet at the base of the bluff on the western boundary. However, the average fill depth is approximately 1 to 3 feet in the western portion of the site.

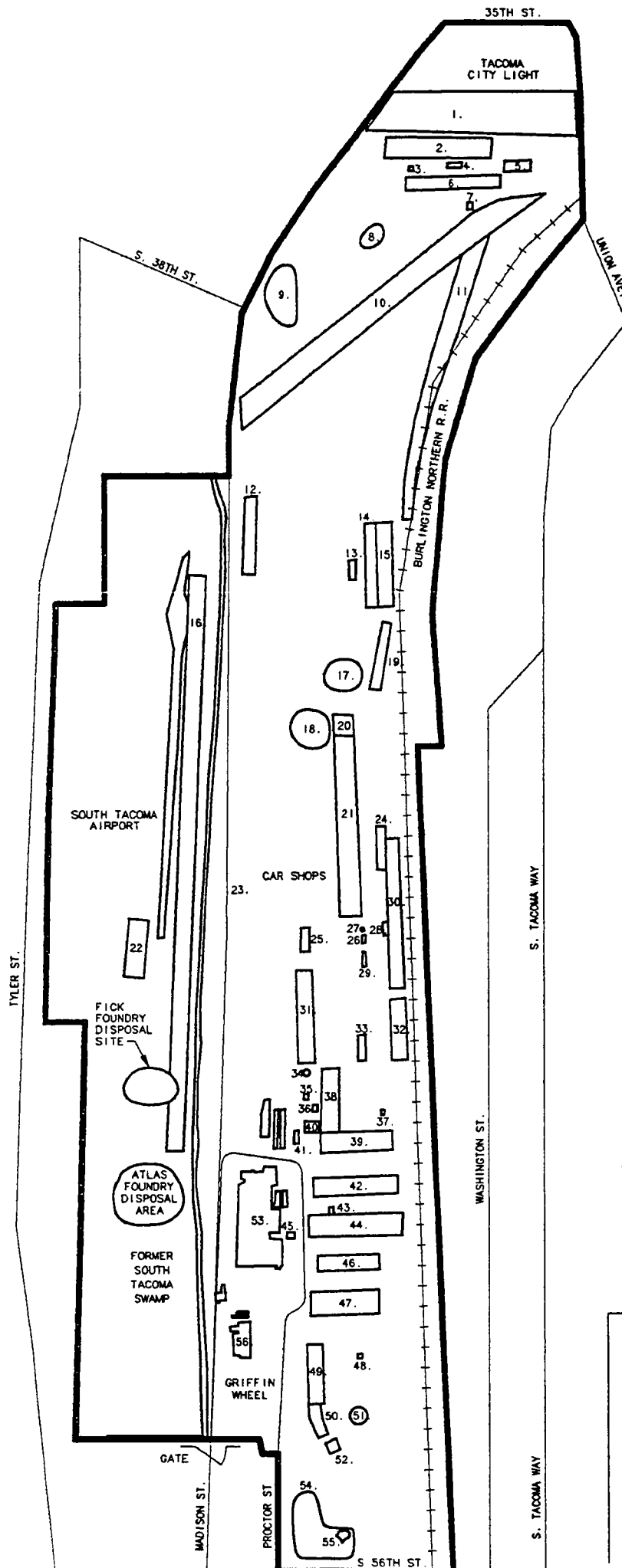
The fill material constituents vary, depending on the industrial operations and filling activities that occurred at particular locations and time. Fill components include cinder, slag, scrap metal, brick, and glass. Cinder is the most common fill material, albeit large quantities of slag are apparent over extensive areas of the STF site. Local deposits of lime and sulfur are evident in the southern portion of the site, but these deposits are small in comparison to quantities of other fill materials.

1.4 SITE HISTORY

This section presents a brief discussion of the historical activities at the STF site and has been prepared based on material contained in the Site Background Summary Report (ICF 1990a). A more complete description of the STF site history is available in the ICF Site Background Summary Report, along with references to other documents that provide additional information on historical site use.

Historical activities at the STF site are illustrated in Figure SS-1. ICF's (1990a) report presents the STF site history based on the historical use of the following geographical areas:

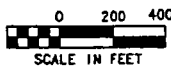
- South Tacoma Car Shops
- Griffin Wheel Company



LEGEND

STF-NPL SITE BOUNDARY

1. TCL YARD AREA
2. GANTRY CRANE AREA
3. FUEL TANK
4. SHED
5. LANTERN SHED
6. STOREHOUSE, BELTHOUSE
ROLLING MILL, STORAGE BLDG
7. FUEL CELLAR
8. BURN PIT
9. TRASH DUMP
10. STORAGE YARD
11. RUBBISH TRACK CORRIDOR
12. CONCRETE CASTING PLANT
13. SANDBLAST SHED
14. BLACKSMITH SHOP
15. CONCRETE FLOOR
16. LANDING STRIP
17. TRASH BURNING AREA
18. TRASH PIT (PAINT SHOP)
19. CAR CASTINGS PLATFORM
20. PAINT SHOP
21. CAR SHOP
22. AIRPORT BLDG
23. MADISON STREET
24. OPEN SHED
25. DRY KILN
26. WASTE SOAKING VAT
27. UST (OIL)
28. PAINT SHOP
29. PAINT HOUSE
30. FREIGHT REPAIR SHED
31. FINISHED LUMBER SHED
32. WHEEL SHOP
33. GENERATOR HOUSE
34. UST (OIL)
35. PUMPS
36. DIP TANK
37. DROP PIT
38. WOODWORKING SHOP
39. COACH SHOP
40. BOILER HOUSE
41. OIL TANKS
42. PAINT SHOP
43. BRASS
44. MACHINE SHOP
45. SOLVENT SHED
46. BOILER, TIN TANK, AND
COPPER SHOP
47. SOUTH MACHINE SHOP
48. TRASH BURNER
49. BLACKSMITH SHOP
50. IRON & STEEL STORAGE
51. TURNTABLE
52. COKE & COAL
53. FORMER IRON FOUNDRY
54. RAILCAR CLEANOUT AREA
55. BURIED DRUMS (REMOVED)
56. FORMER BRASS FOUNDRY SITE



BASE MAP REFERENCE
WALKER & ASSOC. 10-22-86
SURFACE DEBRIS SAMPLING PLAN
FEBRUARY 1987
FOR SITTS & HILL ENGINEERS, INC.
RETEC REMEDIATION TECHNOLOGIES, INC.
SOUTH TACOMA SWAMP

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

**MAJOR HISTORICAL USES
OF THE STF SITE**

916055.06/P1SK096

FIGURE SS-1

- South Tacoma Airport
- South Tacoma Swamp.

The site history summary in this report follows the same format used by ICF (1990a).

1.4.1 South Tacoma Car Shops

The South Tacoma Car Shops area, located in the central section of the STF site along the eastern boundary in Figure SS-1, was used by the Northern Pacific Railroad [later, Burlington Northern Railroad (BNR) Company] as a railcar manufacturing and equipment repair facility. Northern Pacific Railroad operated the site from the early 1890s until 1974. Activities in the Car Shops area included railcar cleaning, painting, steel fabrication, and engine and equipment repair and maintenance. Engines and railcars were dismantled and parts salvaged in the northern section of the Car Shops area.

The industrial operations of the Car Shops area required the use of fuel, oil, grease, and solvents. Waste products were burned or discarded in trash pits located in the STF site. ICF's (1990a) Site Background Summary Report speculated that oil, paint, and other hazardous substances may have been discarded (e.g., spilled) on the site during handling of these materials.

1.4.2 Griffin Wheel Company

Griffin Wheel, currently a division of Amsted Industries, operated a brass and iron foundry in the southern portion of the STF site (Figure SS-1). The Griffin Wheel brass foundry, which operated from 1897 to 1980, was demolished in 1989. The brass foundry manufactured journal bearings which are Babbitt-lined brass casting

used on railcar axles. Griffin Wheel produced the bearings from raw material and recasted used bearings. The brass material contained lead, tin, copper, and zinc. Babbitt material contained lead, tin, antimony, copper, and zinc.

The iron foundry produced iron wheels until 1957. The facility is currently used for other manufacturing processes (see Section 1.5).

1.4.3 South Tacoma Airport

The South Tacoma Airport operated from 1936 to 1973 at an approximately 70-acre site located along the western edge of the STF site (see Figure SS-1). The airport provided aircraft refueling and maintenance service. The airport was reportedly closed for a several year period from 1950 to approximately the mid-1950s. One of two runways was made of oil mat, formed by spreading and rolling out rock and sand and then spraying the prepared surface with paving oil (ICF 1990a).

According to the last owner of the airport, small quantities of oil and solvents were used for maintenance operations. Excess oil was reportedly stored in barrels and disposed of at an offsite facility. When the airport closed, the underground fuel tanks were reportedly excavated and removed (ICF 1990a).

1.4.4 South Tacoma Swamp

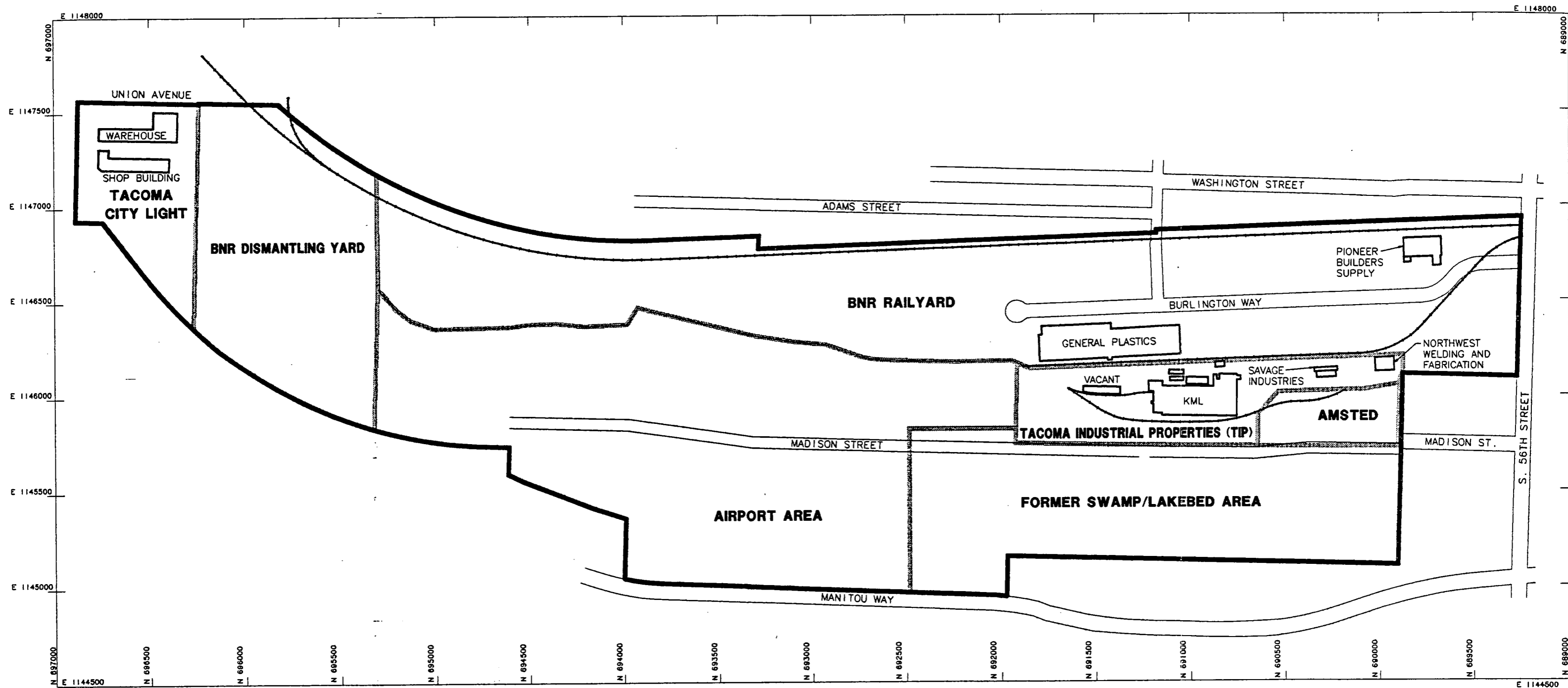
At one time, the South Tacoma Swamp apparently covered a large area extending from South 40th Street to Steilacoom Boulevard (approximately 2 miles south of South 56th Street). A section of the swamp included a small lake and an unregulated dump below the south side of South 56th Street. Historical records also include documentation that two other lakes and a pond were present south of the airport site until approximately 1953 (ICF 1991a).

Atlas Foundry transported wastes from its facility located in the Commencement Bay Tideflats area to the STF site for disposal. Foundry wastes (casting sands and binders, slag, rock, and floor sweepings but not baghouse waste) were disposed of in a lowland section of the South Tacoma Swamp southwest of the airport site from approximately 1968 to 1980. Atlas Foundry halted disposal in 1980 following a regulatory agency inspection.

1.5 CURRENT SITE USE

Much of the STF site is currently undeveloped and is covered with field grass, blackberries, shrubs, and a few trees. Concrete rubble, old foundations, and trash are apparent in some areas. A portion of the STF site is used for light industrial and commercial operations. Some businesses have operated from facilities previously used in association with the iron foundry and the railyards, while other manufacturers have constructed new facilities. Information in this section has been prepared using the Site Background Summary Report (ICF 1990a). A map of businesses currently operating at the STF site is shown in Figure SS-2.

Tacoma Public Utilities (Tacoma City Light) provides electrical service and drinking water to Tacoma residents and businesses, and has operated from the northernmost end of the STF site since 1953. Tacoma Public Utilities uses its facility for maintenance and repair of equipment, as a storage and distribution center for electrical and water supply system components, and as an administration center. The Tacoma City Light property is covered with asphalt pavement and buildings. Stormwater runoff drains to modified dry wells that have soil bottoms and interconnecting piping leading to the City of Tacoma's storm drainage system. Some of the dry wells have been plugged with bentonite to prevent surface water infiltration. A typical cross-section of a plugged dry well is presented in Figure SS-3.



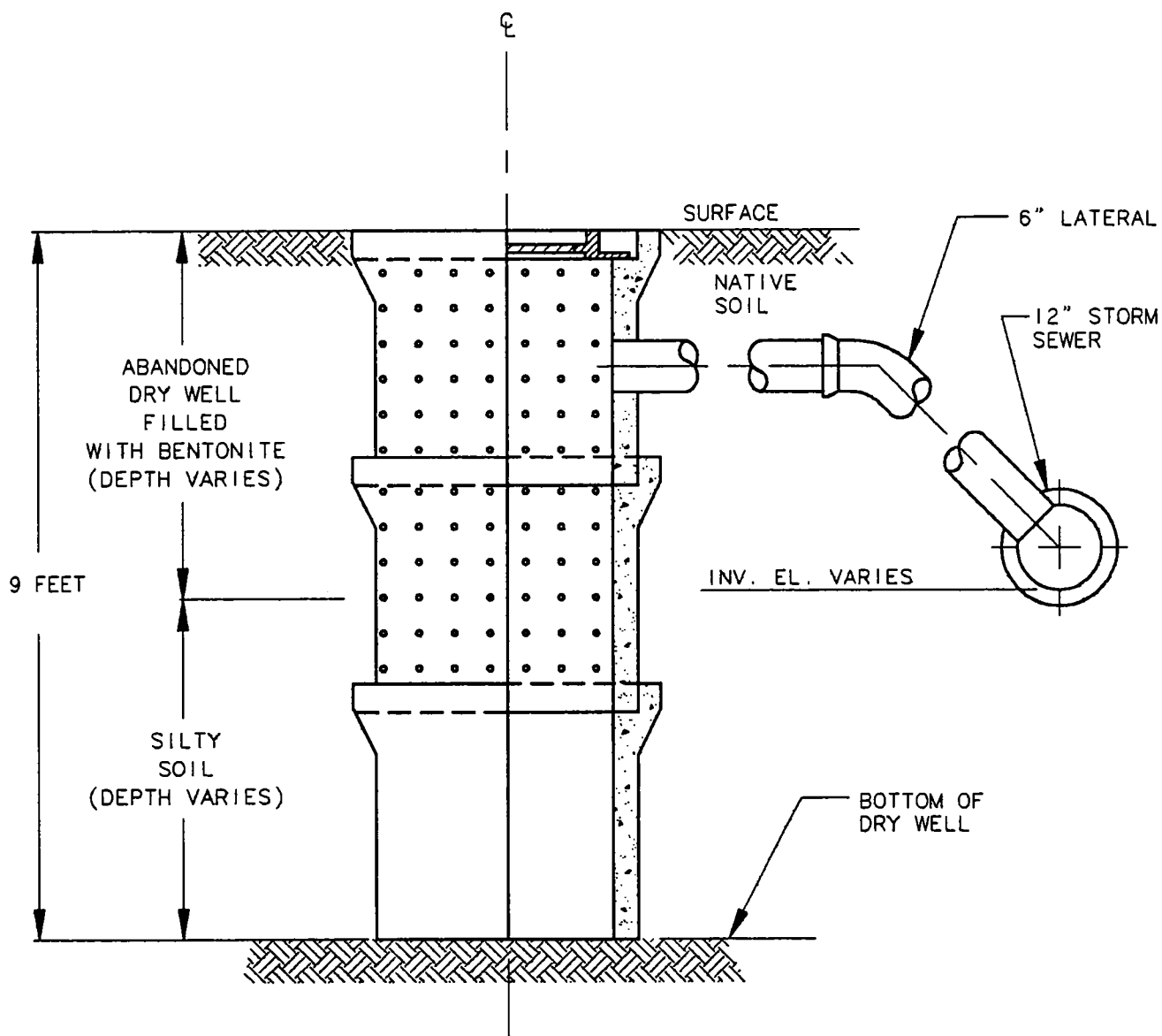
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

**SAMPLING UNIT DESIGNATIONS AND
BUSINESSES CURRENTLY
OPERATING AT THE STF SITE**

916055.06/P1SK098

FIGURE SS-2



PARTIAL SECTION

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

**TYPICAL CROSS SECTION
OF DRY WELL AT
TACOMA CITY LIGHT**
916055.06/P1SK097

FIGURE SS-3

The property has five underground tanks and three aboveground tanks that are used to store automotive fuel, waste oil, and new, used, and waste mineral oil. The underground tanks contain leaded and unleaded gasoline, diesel fuel, and waste oil. The gasoline tanks reportedly are constructed of bare steel and are not equipped with cathodic protection or containment systems. The diesel tank is constructed of fiberglass, and the waste oil tank is constructed of concrete. The aboveground tanks, which contain mineral oil, are located in enclosed areas with complete secondary containment.

In addition to the tanks, Tacoma City Light stores electrical equipment, including approximately 3,500 new and used transformers. Some of the transformers might contain or have previously contained polychlorinated biphenyls (PCBs). Other hazardous substances stored at Tacoma City Light include PCBs, PCB-contaminated mineral oil, pesticides, and herbicides. PCB contamination of Tacoma City Light soil has been documented by Black & Veatch (1983) and by Hart-Crowser (1989). Other chemicals of concern, including solvents, could have been used onsite for equipment cleaning and maintenance.

Tacoma Industrial Properties (TIP) Management Inc. owns property in the central portion of the STF site and uses the area for a variety of industrial purposes. Three businesses operate on TIP property: KML Corporation, Savage Industries, and Northwest Welding and Fabrication. KML Corporation has operated in the old iron foundry building since 1986. KML laminates films onto particle board for the construction of cabinets and interior partitions. Savage Industries has used a former BNR wood patterns and vaults building since the early 1970s to manufacture wood picture frames. Northwest Welding and Fabrication has operated at TIP since 1986. Northwest Welding and Fabrication activities include repair of boats, motors, and boat trailers, as well as steel product fabrication and repair.

Other businesses have used TIP facilities; however, little information is available about their operations. These businesses reportedly included steel tubing, bending, and fabrication; lamination of plastic overlays on particle boards; railroad wheel

journal bearing manufacturing; soil stabilization materials manufacturing; warehousing; and steel fabrication.

Facilities recently constructed on STF site property include the General Plastics and Pioneer Builders Supply complexes. General Plastics built a manufacturing plant in 1981 on a portion of the former Northern Pacific Car Shops area. General Plastics manufactures high-density rigid and flexible polyurethane foams and high-density rigid polyisocyanurate foams for the aviation, construction, marine, nuclear, architectural, and sports equipment industries. General Plastics uses and/or stores onsite several chemical products including chlorofluorocarbons, methylene chloride, and isocyanates. One underground storage tank is used for spill containment purposes.

Pioneer Builders Supply purchased land in the southeast portion of the STF site for a warehouse and office building that were constructed in 1988. Pioneer Builders Supply operates a distribution center for asphalt and cedar roofing materials. Pioneer Builders Supply uses two underground tanks to store diesel fuel and gasoline. Three underground tanks were discovered in the northeast corner of the property in early 1990 and were excavated and disposed of in June 1990 (Hildenbrand, J., 12 February 1991, personal communication).

1.6 PREVIOUS INVESTIGATIONS

A review of previous investigations conducted in the South Tacoma Channel area indicate that, in general, surface soil samples were not collected in locations outside the boundary of the STF site. However, in one investigation related to chemicals of concern detected in the City of Tacoma public well 12A (EPA 1984), nine surface soil samples (including one duplicate sample) were collected along the BNR tracks in the vicinity of Fife Street and Prospect Street (see Figure SS-4 in Section 2.1).

Six samples were analyzed for volatile organic compounds and three samples were analyzed for organic priority pollutants (excluding pesticides). Detected compounds include 1,1,2,2-tetrachloroethane (maximum concentration of 300 $\mu\text{g/kg}$), tetrachloroethylene (maximum concentration of 300 $\mu\text{g/kg}$), and trichloroethylene (56 $\mu\text{g/kg}$). Other compounds, including carbon tetrachloride, acetone, and toluene were detected, but were not quantified (i.e., reported concentrations were detected near the quantitation limits).

1.7 IDENTIFICATION OF SAMPLING UNITS

For the purpose of investigation, the STF site was divided into six areas based on the historical activities described above and the potential for those activities to cause chemicals of concern to be released to the environment. In addition, each area (except Tacoma City Light) was designated as high, medium, or low based on perceived-risk from elevated concentrations of chemicals of concern detected in onsite surface soil. Those designations formed the basis for sampling grid sizes. The high-perceived risk areas had the smallest grid size and the low-perceived risk areas had the largest grid size (see Section 2.2.1).

2.0 INVESTIGATIVE METHODS

This section contains a description of the background and onsite sampling for the Phase I Soil Investigation, including a summary of the surface soil sampling rationale, collection methods, sampling locations, and analytical parameters. This section also includes a discussion of the focused subsurface soil investigations at Tacoma City Light and Pioneer Builders Supply.

2.1 BACKGROUND SURFACE SOIL SAMPLING

An understanding of the presence and concentrations of chemicals of concern in surface soil at offsite locations is required to evaluate baseline soil conditions in the vicinity of the site and to assist in development of soil cleanup levels for the STF site. Offsite (background) surface soil samples were collected and analyzed to compare background concentrations to those detected in STF onsite surface soil.

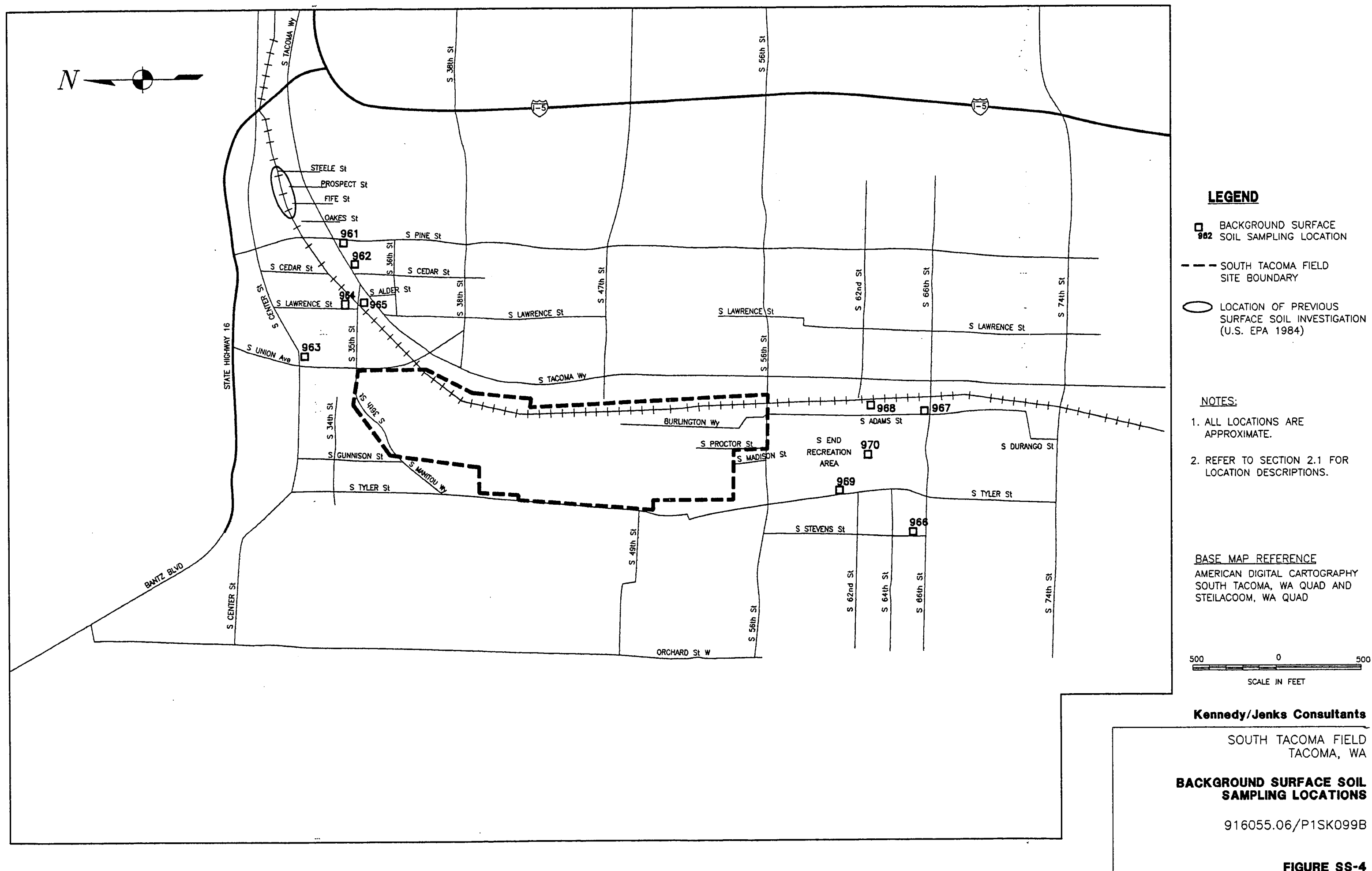
Samples were collected from offsite areas that appeared to be within the South Tacoma Channel, the same geomorphic feature in which the STF site is situated. Samples collected offsite, but within the South Tacoma Channel, were intended to provide representative background information on soil conditions in the vicinity of the STF site.

Eleven surface soil samples were collected from 10 offsite locations situated north and south of the STF site. The approximate background surface soil sampling locations are described in Table SS-1 and shown in Figure SS-4. Analytical results for the background samples are presented in Sections 4.1.1 and 4.2.1.

TABLE SS-1**BACKGROUND SURFACE SOIL SAMPLE LOCATIONS**

Background Sample Location No.	Direction from STF Site	Sampling Location
961 & 971(a)	North	Hillside west of Pine Street between South Tacoma Way and South 36th Street
962	North	Small grassy area south of South Tacoma Way and east of South Cedar Street
963	North	Grassy hillside on the south side of Center Street near the intersection of South Union Avenue and South Center Street
964	North	Near railroad tracks at the intersection of Lawrence Street and South 35th Street
965	North	Grassy area at intersection of Alder Street and South Tacoma Way
966	South	Grassy hillside east of Stevens Street and south of South 64th Street
967	South	Grassy area on the north side of South 66th Street between South Adams Street and the Burlington Northern Railroad tracks
968	South	Grassy area in empty lot south of South 62nd Street on east side of South Adams Street
969 & 970	South	Within the South End Recreational Area (one location along the west central property boundary and one location near the central portion of the park)

(a) Sample 971 was collected at a later date than sample 961 in order to provide a split sample with the U.S. EPA.



2.2 ONSITE SURFACE SOIL SAMPLING

2.2.1 Surface Soil Sampling Units

EPA defined three categories of sampling units for the STF property. These units are defined as high-, medium-, and low-perceived risk areas based on preliminary evaluations of data on existing concentrations of chemicals of concern in soil at the STF site.

The sampling density for each perceived-risk area was developed with the objective of locating a hot-spot (i.e., area of elevated concentrations of chemicals of concern in soil) of a certain size with a specific probability. For the high-perceived risk areas, a 70-foot grid system was used to identify a circular hot-spot one-eighth of an acre in size with 95-percent probability. For the medium-perceived risk areas, a 150-foot grid system was used to detect a hot-spot one-half acre in size with 90-percent probability. For the low-perceived risk areas, a 235-foot grid system was used to detect a hot-spot 1 acre in size with 80-percent probability.

Surface soil samples were collected at the grid nodes (i.e., intersection of grid lines) of the medium- and low-perceived risk sampling units. In the high-perceived risk sampling units, a composite soil sample was collected from the grid center and four other equally spaced sampling points within the grid [see Standard Operating Guideline (SOG)-10 in Appendix A of the FSAP (Kennedy/Jenks/Chilton 1991b)].

The grids were numbered sequentially beginning in the northeast corner of BNR Dismantling Yard. Surface soil samples were not collected from Tacoma City Light because the area is paved and covered by buildings. Reference Maps 1 and 2 in the Reference Appendix present detailed illustrations of the sampling location numbering system. Sampling locations were assigned numbers 250 through 915 (each sampling location was assigned a unique number, see Reference Map 1 in the Reference Appendix). Sample location numbers 950 and 951 were assigned to sampling locations within Amsted that were not identified during the initial sampling

grid survey for the site. Additional sampling locations were also included where specific analyses (e.g., dioxins and furans) were required. For example, location numbers 952 and 953 were used for the dioxin and furan analysis of samples collected from the burn area.

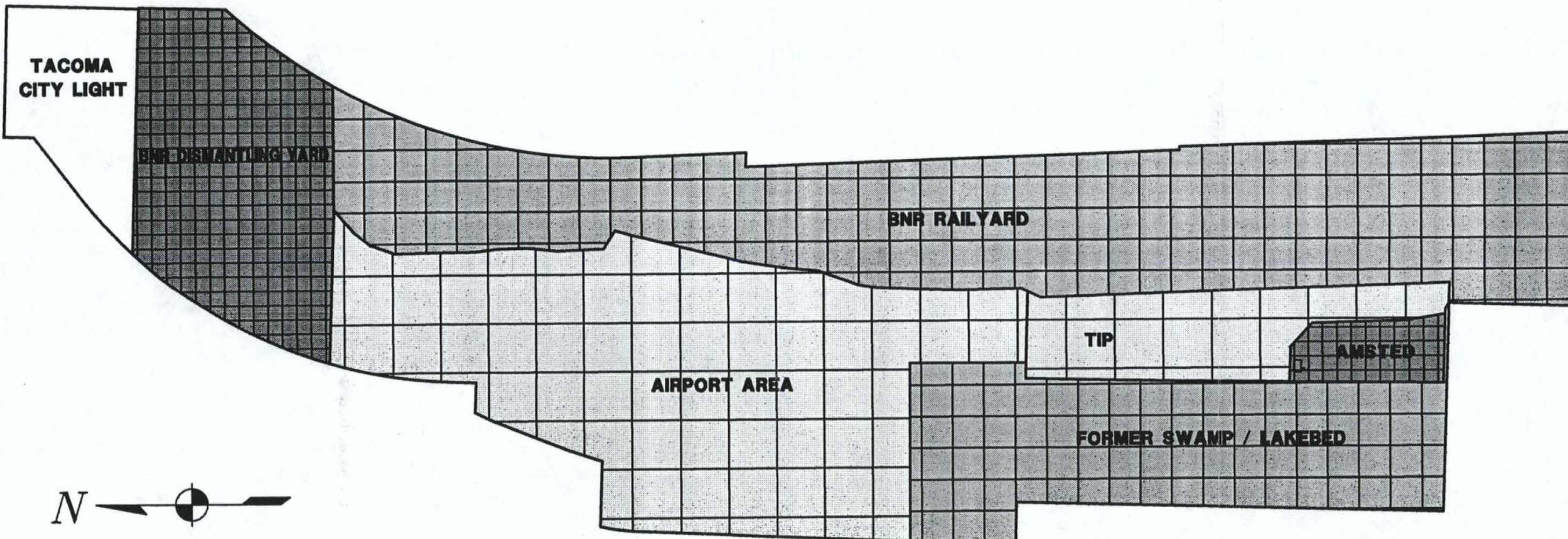
In the 70-foot grids for the BNR Dismantling Yard and Amsted, the location number represents the center position of the grid. In all other sampling areas, the location number represents the grid node. The boundaries of the six sampling units and the approximate sampling locations are illustrated in Figure SS-5.

Table SS-2 presents a summary of the sampling unit names, grid sizes, number of samples collected, and analytical parameters for the onsite soil sampling. Additional sampling location information is provided in Table 4-6 of the Data Appendix.

Occasionally, sampling locations deviated from the preestablished sampling points. In the high-perceived risk areas, sampling points were relocated to locations of obvious surface evidence of contamination (e.g., slag, oil-stained soil, barren areas, and stressed vegetation). In all risk areas, some alternate locations were sampled to avoid obstructions (e.g., building foundations, thick patches of blackberry bushes, and existing buildings). In the case of obstructions, alternate sampling points were located as close as possible to the original sampling point. If the entire grid area was inaccessible, a sample was not collected. Reasons for deviating from the preestablished sampling locations were noted in field logbooks. Locations where samples could not be collected are identified with an asterisk (*) in Table 4-6 of the Data Appendix.




2.2.2 Tacoma City Light Subsurface Soil Sampling Locations

During construction of the Tacoma City Light facility, dry wells (see Figure SS-3 of Section 1.3) were installed in the large paved areas. These dry wells allowed for



LEGEND

PERCEIVED RISK LEVEL DESIGNATION (GRIDSIZe)

	HIGH (70- ft)
	MEDIUM (150 ft)
	LOW (235 ft)

BASE MAP REFERENCE
ICF TECHNOLOGY INCORP.
FINAL WORK PLAN
SAMPLING LOCATIONS FOR
SOILS AND SEDIMENTS
SEPTEMBER 1990

NOTES:

1. GRID NODES REPRESENT APPROXIMATE SAMPLING LOCATIONS.
2. AT THE AMSTED AND BNR DISMANTLING YARD SAMPLING UNITS, SAMPLES WERE COLLECTED AT THE CENTER AND AT FOUR EQUALLY SPACED LOCATIONS WITHIN THE GRID AND COMPOSITED TO FORM ONE SAMPLE.
3. AT THE BNR RAILYARD, TIP, FORMER SWAMP/LAKEBED, AND AIRPORT SAMPLING UNITS, SAMPLES WERE COLLECTED FROM THE GRID NODES (I.E., THE INTERSECTION OF THE GRID LINES).

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

**SURFACE SOIL SAMPLING AND
RISK DESIGNATION AREAS**

916055.06/P1SK100

FIGURE SS-5

TABLE SS-2

**ONSITE SURFACE SOIL SAMPLING UNITS, GRID SIZE,
NUMBER OF SAMPLES COLLECTED, AND ANALYTICAL PARAMETERS**

Sampling Unit^(a)	Sampling Grid Size (feet)	Perceived Risk	Number of Samples Collected^(b)	Analytical Parameters
BNR Dismantling Yard and Amsted	70	High	325	<ul style="list-style-type: none">• 69 - TCL^(c)• 256 - PAH, Metals, and Boron
Former Swamp/Lakebed and BNR Railyard	150	Medium	246	<ul style="list-style-type: none">• 51 - TCL• 195 - PAH, Metals, and Boron
Airport and TIP	235	Low	51	<ul style="list-style-type: none">• 10 - TCL• 41 - PAH, Metals, and Boron

(a) See Reference Maps 1 and 2 in the Reference Appendix for sampling locations.

(b) Number of samples includes duplicates.

(c) TCL - Denotes Target Compound List which includes analyses identified in Section 2.3.1.

the recharge of the local groundwater by precipitation that would otherwise be diverted to the storm sewer.

During an investigation by Hart-Crowser (1989), PCBs were detected in dry well sediments. Dry wells where PCBs were detected were subsequently sealed with bentonite plugs to reduce the potential for further downward migration of chemicals of concern.

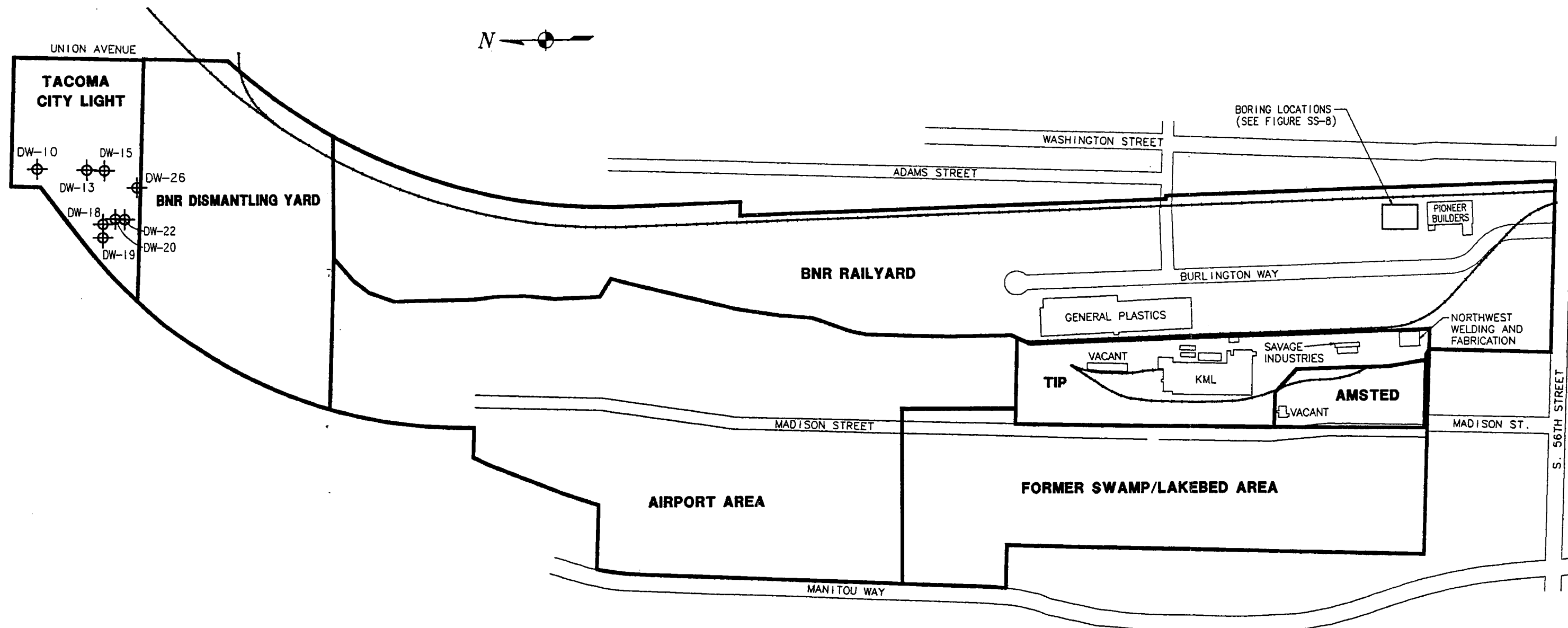
To evaluate the vertical distribution of chemicals of concern, one soil boring was advanced through each of eight dry wells into the underlying soil. Four samples from each dry well were collected for a total of 32 samples. These samples were analyzed for the full Target Compound List (TCL) parameters (as described in Section 2.3). Boring locations are shown in Figures SS-6 and SS-7.

2.2.3 Pioneer Builders Supply Subsurface Soil Sampling Locations

Excavation of three underground tanks on Pioneer Builders Supply property in May 1990 and subsequent sampling and analysis revealed the presence of several TCL chemicals in soil (Hildenbrand, J., 12 February 1991, personal communication). To determine the subsurface distribution of the concentrations of these chemicals of concern, five soil borings were advanced in and adjacent to the former tank removal excavation area during the Phase I Soil Investigation. Boring locations are shown in Figures SS-6 and SS-8. One of the borings in the center of the excavation was completed as a monitoring well NMW-1A.

2.3 SOIL SAMPLE COLLECTION PROCEDURES AND ANALYTICAL PARAMETERS

This section describes the sample collection procedures and analytical parameters for Phase I surface and subsurface soil sampling.



LEGEND

DW-10  TACOMA CITY LIGHT
 DRY WELL LOCATION

0 500
 SCALE IN FEET

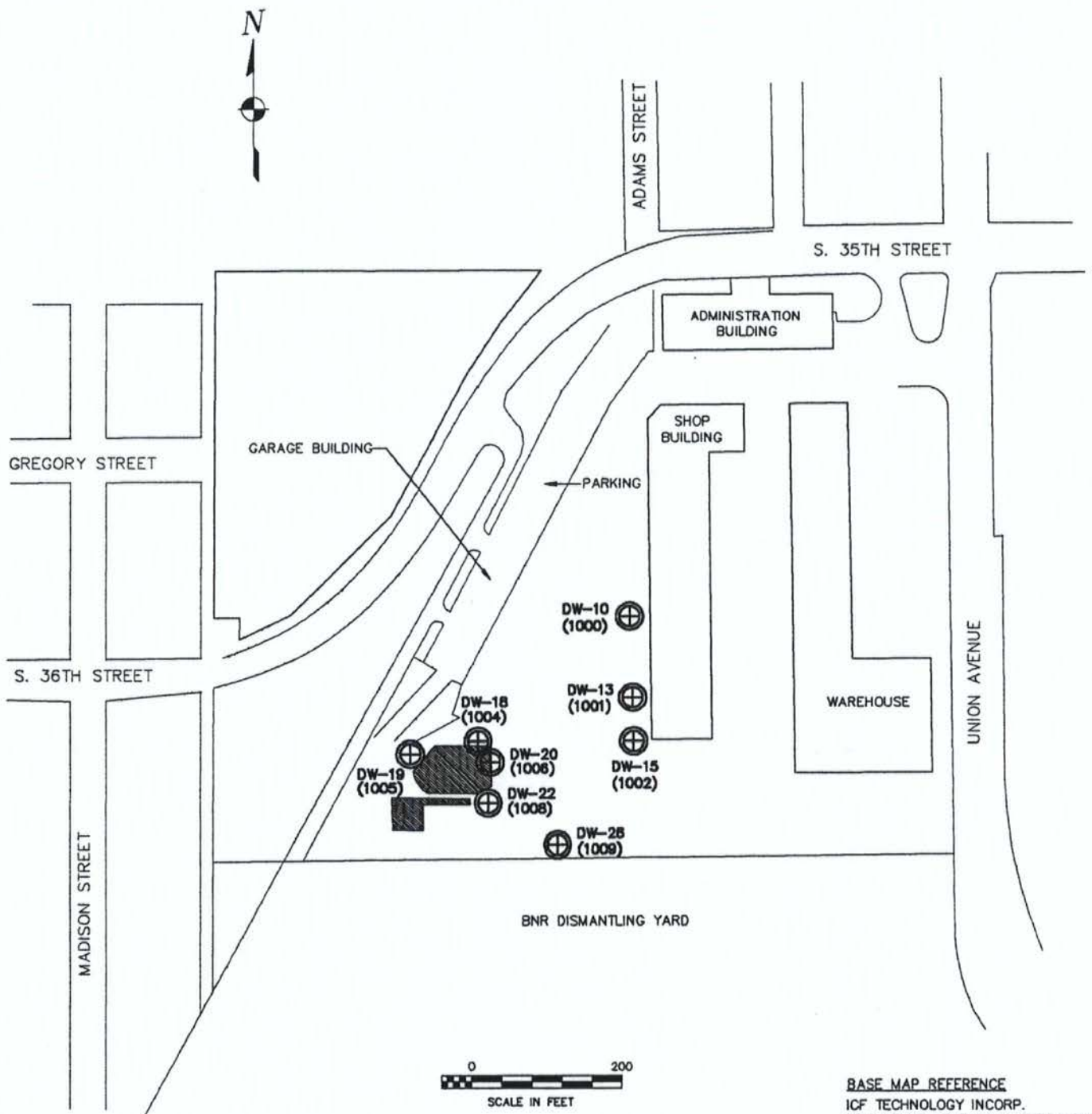
Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
 TACOMA, WA

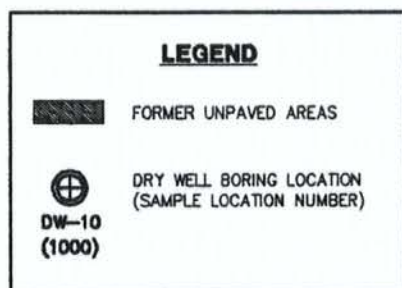
**BORING LOCATIONS
 PHASE I SOIL INVESTIGATION**

916055.06/P1SK116

FIGURE SS-6



BASE MAP REFERENCE
ICF TECHNOLOGY INCORP.
DRY WELLS AT TACOMA CITY LIGHT
JUNE 12, 1990



Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

**TACOMA CITY LIGHT
DRY WELL BORING LOCATIONS**

916055.06/P1SK102

FIGURE SS-7



LEGEND

NMW-1A

MONITORING WELL BORING

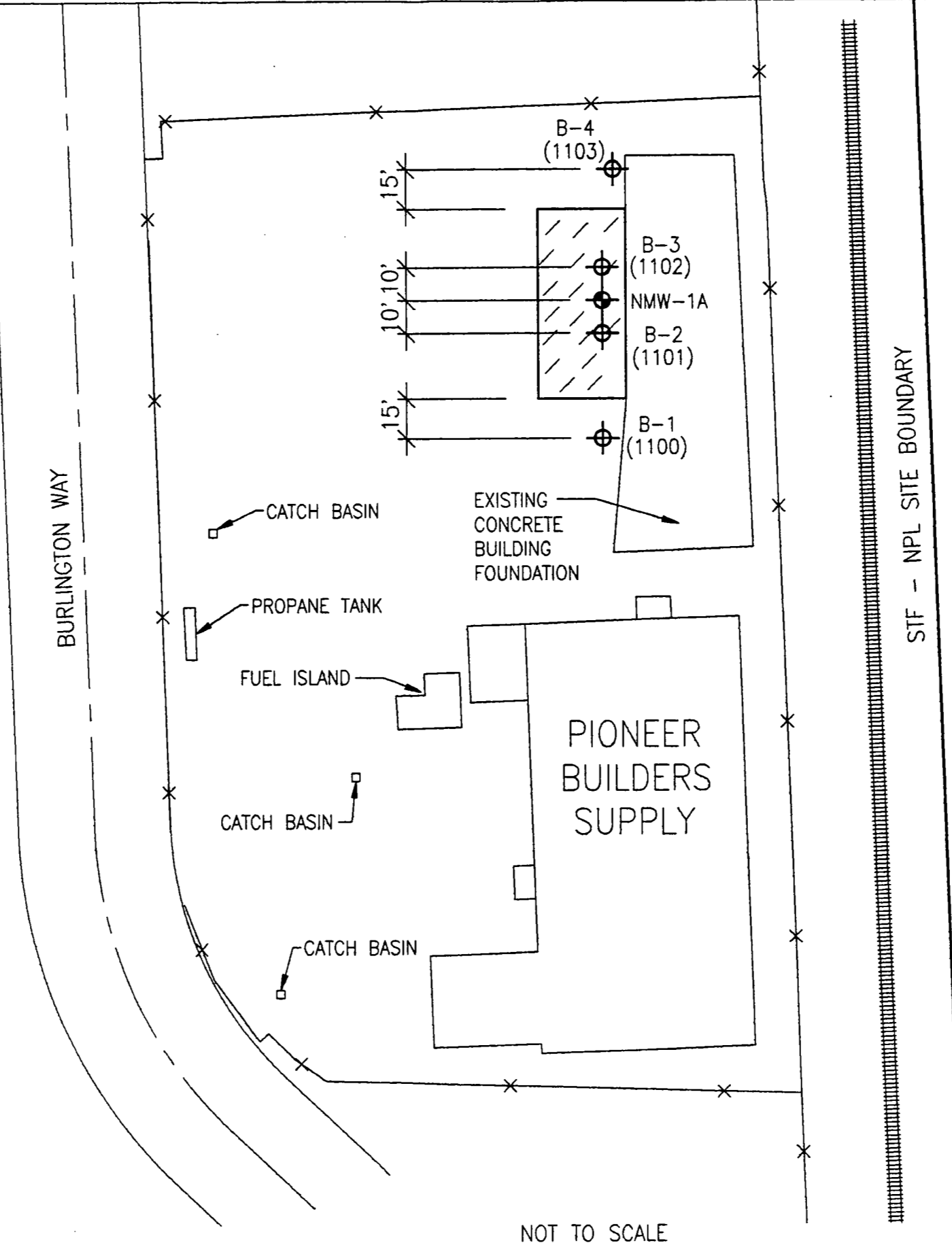
B-1
(1100)

BORING LOCATION (SAMPLE LOCATION NUMBER)

UNDERGROUND TANK EXCAVATION

EXISTING RAILROAD TRACKS

EXISTING FENCE



NOTES:

- 1) ALL LOCATIONS ARE APPROXIMATE.
- 2) APPROXIMATE TANK LOCATIONS ARE BASED ON PHOTOGRAPHS TAKEN AT THE TIME OF TANK REMOVAL.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA.

**PIONEER BUILDERS SUPPLY
BORING LOCATIONS**

916055.06/P1SK115

FIGURE SS-8

2.3.1 Background Surface Soil

Vegetation and other non-soil material were removed prior to collecting surface soil samples. Samples were collected from the ground surface to a depth of 6 inches below ground surface. A clean, stainless steel spoon was used to homogenize the soil in place (i.e., in the sample hole). Samples were then placed in clean glass jars. The jars were immediately capped, labeled, put in plastic bags, and then placed in coolers having an internal temperature of 4°C or less.

Samples were collected for volatile organic compound analyses by driving a slide hammer soil sampler into the uppermost layer of soil. This sampler was fitted with a clean, stainless steel cylindrical tube, 6-inches long and with a 2-inch diameter. The tube was removed from the sampler and the ends were covered with teflon paper and plastic caps. The plastic caps were sealed with teflon tape, and the sample was labeled, put in a plastic bag, and placed in a cooler.

Samples were prepared for shipment to the laboratory by packing the samples in a cooler with ice to maintain an internal temperature of 4°C or less. The coolers were taped closed and custody seals were attached. Coolers were sent to the analytical laboratory via courier or overnight air delivery. Chain-of-custody procedures, as detailed in the STF Quality Assurance Project Plan (Kennedy/Jenks/Chilton 1991c) were strictly followed.

All background samples were analyzed for the TCL parameters, which includes the following analyses:

- Volatile organic compounds (VOCs) - EPA-Contract Laboratory Program (CLP) (EPA 1990a).
- Semivolatile organic compounds - EPA-CLP (EPA 1990a) and EPA Method 8310 for polynuclear aromatic hydrocarbons (PAHs).

- PCBs - EPA-CLP (EPA 1988b).
- Metals including aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), calcium (Ca), chromium (CrIII), hexavalent chromium (CrVI), total chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), mercury (Hg), nickel (Ni), potassium (K), selenium (Se), silver (Ag), sodium (Na), thallium (Tl), vanadium (V), and zinc (Zn). Metals were analyzed using a variety of analytical techniques outlined in the EPA-CLP (EPA 1990b). Low level copper was analyzed using EPA Method 7211. CrVI was initially analyzed by EPA Methods 1311 (extraction) and 7197 [Toxicity Characteristic Leaching Procedure (TCLP)]. For analytical reasons (e.g., low matrix spike recoveries), the extraction method was later changed to the TCLP method.
- Total cyanide - EPA-CLP (EPA 1990b).

2.3.2 Onsite Surface Soil

Surface soil samples were collected using two basic procedures. In the high-perceived risk areas, a composite sample was collected from each grid area as described in Section 2.2.1. In the medium- and low-perceived risk areas, grab samples were collected at the grid nodes. Sample collection methods were similar to those described for background samples in Section 2.3.1.

In all three perceived-risk areas, samples for VOC analyses were collected using a slide hammer as described in Section 2.3.1. For composite samples collected from the high-perceived risk areas (except those collected for VOC analyses), a stainless steel spoon was used to place soil material in a stainless steel mixing bowl. Approximately equal quantities (determined visually) of soil from each of the five sampling locations within the grid were then mixed thoroughly. After mixing, the soil was spread into a relatively flat pile within the bowl. The pile was then

quartered, and small samples from each quarter were collected until the amount of soil needed to fill the container was acquired. Additional details regarding surface soil sampling procedures are presented in SOG-10, Appendix A of the FSAP (Kennedy/Jenks/Chilton 1991b).

Approximately 20 percent of all samples were analyzed for the full TCL parameters as described in Section 2.3.1. In addition, samples collected for TCL analyses were analyzed for boron (EPA Method 6010). The remaining samples (approximately 80 percent) were analyzed for metals, PAHs, and boron.

For all three perceived-risk areas, a duplicate sample was collected for every 20 samples collected. A computer-generated random numbering program was used to determine the duplicate sampling locations and type of analysis (i.e., full TCL vs PAHs, metals, and boron). The random numbering program was also used to select duplicate sampling locations for approximately 20 percent of each analysis type. Table 4-6 in the Data Appendix lists the analyses performed on each sample.

2.3.2.1 Amsted and BNR Dismantling Yard. Amsted and the BNR Dismantling Yard were identified in the STF Work Plan (ICF 1990b) as high-perceived risk areas. Composite samples were collected from these areas as described in Section 2.3.2. Alternate procedures were used to collect samples from the BNR Dismantling Yard burn pit and trash dump areas (see Reference Map 2 in the Reference Appendix). In the burn pit, grab samples (instead of composite samples) were collected from sampling locations 357 and 386. The samples were collected in locations that appeared to exhibit evidence of burned material. These samples were analyzed for dioxins and furans in addition to the full TCL parameters.

Grab samples were also collected from the BNR Dismantling Yard trash dump. Locations 511, 522, and 548 were sampled from the center of each grid and analyzed for the full TCL parameters.

2.3.2.2 BNR Railyard and Former Swamp/Lakebed. The BNR Railyard and the Former Swamp/Lakebed sampling units were identified as medium-perceived risk areas. Samples were collected from the grid nodes.

In the BNR Railyard, historical records (ICF 1990a) and a reconnaissance indicated that a burn area appeared to exist near sampling location 619. Samples were collected from within this grid in an area that appeared to exhibit evidence of burned material. In addition, extra samples (location numbers 952 and 953) were collected. All samples within the burn area were analyzed for dioxins and furans and the full TCL parameters.

In the Former Swamp/Lakebed area, historical records (ICF 1990a) indicated that several areas were used as disposal locations by Fick Foundry, Atlas Foundry, and others (see Figure SS-1). Several samples were collected from these areas and analyzed for the full TCL parameters.

2.3.2.3 Airport and TIP. The Airport and TIP were identified as low-perceived risk areas. Samples were collected from the grid nodes. No additional samples or special analyses were required for the investigation of these units.

2.3.3 Tacoma City Light Dry Wells

Subsurface soil samples were collected from the Tacoma City Light dry wells using hollow stem auger drilling techniques. Samples were collected by lowering a 2.5-inch x 24-inch stainless steel, split-barrel sampler inside the hollow stem auger. The sampler was driven 2 feet with a 140-pound hammer dropping 30 inches. The sampler was lined with two 3-inch long stainless steel liners adjacent to the drive shoe with three 6-inch liners filling the remainder of the sampler.

Soil borings were advanced in dry wells DW-10, DW-13, DW-15, DW-18, DW-19, DW-20, DW-22, and DW-26 at the locations shown in Figures SS-6 and SS-7. Four

soil samples were collected from each dry well location. After advancing the auger through the bentonite plug in each dry well, an initial sample was collected from the underlying soil. Typically, initial soil samples were collected when the bentonite was fully penetrated. The remaining three samples were collected at 2-, 4-, and 6-feet below the initial sample. Boring logs containing descriptions of the soil conditions encountered in the dry wells are presented in Appendix SS-A.

For each soil sample retrieved from a boring, soil contained in one of the 3-inch liners was packaged for VOC analyses. The remaining soil was extruded from the liners and placed in a stainless steel bowl and homogenized with a stainless steel spoon. Soil was then placed in glass jars. The jars were immediately capped, labeled, put in a plastic bag, and placed in a cooler having an internal temperature of approximately 4°C. At the end of each day, samples were packaged and sent to the laboratory for analysis along with completed chain-of-custody and analytical requests forms. Drilling and sampling methods are described in detail in SOG-11, Appendix A of the STF FSAP (Kennedy/Jenks/ Chilton 1991b).

Sample numbers and cross-references to boring locations are presented in Table 4-7 of the Data Appendix. Subsurface soil samples were analyzed for the full TCL parameters (including boron) as described in Section 2.3.1. Analytical results from the Tacoma City Light subsurface investigation are presented in Sections 4.1.4 and 4.2.4.

2.3.4 Pioneer Builders Supply

Soil borings at Pioneer Builders Supply were also collected using hollow stem auger techniques as described for the Tacoma City Light dry wells (Section 2.3.3). Soil in the upper portion of the drive sampler was extruded, homogenized, and placed into sample containers. Soil in the bottom liner(s) was left undisturbed and sealed for VOC analyses.

One boring was advanced in the center of the former tank excavation (Figure SS-8) to a total depth of approximately 50 feet below grade. This boring was completed as groundwater monitoring well NMW-1A. Four other borings were also advanced on Pioneer Builders Supply property. The two borings closest to NMW-1A (B-2 and B-3) were each drilled to a total depth of 32 feet below grade. These borings were located in the center of the northern and southern thirds of the former tank removal excavation.

Borings B-1 and B-4 were drilled 15 feet south and 15 feet north-northeast, respectively, of the former tank excavation. These borings were advanced to a total depth of approximately 28 feet below grade.

Four samples each were collected from B-2 and B-3 beginning at 17 feet below grade (the approximate bottom of the tank removal excavation), and at 5-foot vertical intervals thereafter to the total boring depth of 32 feet below grade. Five samples were collected from the boring for NMW-1A at 5-foot intervals beginning at 17 feet below grade to a depth of 38 feet below grade. Borings B-1 and B-4 were sampled at the surface, at 3 feet below grade, and then at 5-foot vertical intervals to 28 feet below grade for a total of 7 samples each.

Boring logs containing descriptions of the soil conditions encountered during drilling are presented in Appendix SS-A. Sample numbers and cross-references to boring locations are presented in Table 4-8 of the Data Appendix. All subsurface soil samples collected from these borings were analyzed for PAHs, VOCs, and semivolatiles. Eight randomly selected samples were analyzed for the full TCL parameters, including boron. Analytical results from the Pioneer Builders Supply subsurface investigation are presented in Sections 4.1.5 and 4.2.5.

2.4 SUPPLEMENTAL SURFACE SOIL CHARACTERIZATION

Supplemental soil characterization was required (Addendum 1 of STF FSAP; Kennedy/Jenks/Chilton 1991b) to provide data for evaluating the effectiveness of potential remedial technologies. To provide data for these requirements, 40 soil samples were collected from the six sampling units and in the vicinity of the surface water channel (located in the Airport) and tested for geotechnical properties. In addition, total organic carbon (TOC) analyses were also performed. Information regarding sample locations and the tests performed on each sample is presented in Table SS-3.

Samples were collected from staked locations (center of the grid in the BNR Dismantling Yard and Amsted; grid nodes in all other areas) where soil appeared to be representative of the surface soil within the sampling unit.

As part of the air investigation (another separate component of the STF RI), a composite sample was collected primarily for chemical analyses from each of the six sampling units; however, additional tests were performed (see footnote "c" in Table SS-3). The six composite samples consisted of soil material collected from each of the other sampling points (within each sampling area) used to supply material for geotechnical testing. These composite samples were analyzed for metals, boron, and PAHs. Analytical results will be used for assessing chemical mobility in the atmosphere (e.g., chemicals of concern adsorbed to airborne particulates). Results will be discussed in the Air Investigation Report.

Because much of the onsite soil is coarse-grained, containing gravel and cobbles in many areas, an undisturbed field sample (required for permeability and bulk density testing) could not be collected. Instead, in-situ measurements were taken for density and moisture (EPA concurrence given in letter dated 17 July 1991). These data were used by the laboratory as the target values to recompact disturbed samples for permeability testing.

TABLE SS-3

**GEOTECHNICAL SAMPLING UNITS, SAMPLE LOCATIONS,
AND NUMBER OF SAMPLES COLLECTED**

Sampling Unit	Sample Locations Used for Geotechnical Tests^(a)	Sample Locations Used for Particle Size Analysis^(b)	Composite Sample Location Number^(c)
BNR Dismantling Yard	325, 341, 485	255, 448	990
Former Swamp/Lakebed	747, 770, 821	804, 880	991
Airport	599, 611, 643, 667	555, 697	992
Amsted	799, 847	819, 829	993
BNR Railyard	586, 703, 780, 895	649, 740	994
TIP	716, 726	727, 745	995
Surface Water Channel	668, 766, 878, 2516 ^(d)	NR ^(e)	NR
TOTAL	22	12	6

- (a) These samples were analyzed for total organic carbon (EPA Method 9060), sieve analysis (ASTM D-1140, ASTM C-136, and ASTM D-2487), moisture content (ASTM D-2216), Atterberg limits (ASTM D-4318), specific gravity (ASTM D-854), compaction (ASTM D-1557), in-situ density (ASTM D-2922), in-situ water content (ASTM D-3017), permeability (ASTM D-5084), and bulk density (ASTM D-2937).
- (b) Two additional samples were collected from each of the sampling units, except the surface water channel, for a total of 12 samples. These samples were used only for particle size analyses (ASTM D-1140, ASTM C-136, and ASTM D-2487).
- (c) Composite samples were analyzed for total organic carbon (EPA Method 9060), sieve analysis (ASTM D-1140, ASTM C-136, and ASTM D-2487), moisture content (ASTM D-2216), Atterberg limits (ASTM D-4318), specific gravity (ASTM D-854), and compaction (ASTM D-1557).
- (d) Surface water channel delineation location number.
- (e) NR - Samples not required by STF FSAP (Kennedy/Jenks/Chilton 1991b).

All soil samples (except the composite samples) were collected using a clean shovel and placed in a plastic bag lining a 5-gallon bucket. Composite samples were collected using a clean stainless steel spoon, and placed in a 5-gallon bucket lined with aluminum foil. Supplemental soil characterization analytical results are presented for each sampling unit in Section 4.3.

2.5 DECONTAMINATION PROCEDURES

Decontamination procedures are necessary to protect site workers (personal decontamination), prevent cross-contamination between sampling locations (equipment decontamination), and manage investigation-derived wastes.

Personal decontamination guidelines are presented in SOG-1 of Appendix A in the STF FSAP (Kennedy/Jenks/Chilton 1991b). Equipment decontamination procedures are outlined in SOG-2 of the FSAP.

Investigation-derived wastes included soil cuttings from the Tacoma City Light dry wells and Pioneer Builders Supply borings, disposable personal protective clothing, wash water, and decontamination wastes. These materials were typically placed in lined, Department of Transportation-approved, 55-gallon steel drums or bulk containers and stored onsite. All drums were labeled as to their contents. Other information, including date, origin, and the level of personal protective equipment used during waste production (e.g., level D or level C) was also provided. Representative samples were collected from each waste type and submitted for characterization using laboratory analyses. Wastes were then disposed of as required based on their characterizations.

Disposable clothing from level D areas was cleaned and placed in plastic garbage bags and disposed of as nonhazardous waste. Disposable clothing that could not be cleaned or that originated from a level C area is stored onsite in preparation for disposal.

3.0 QUALITY ASSURANCE, DATA VALIDATION, AND STATISTICAL ANALYSES

3.1 FIELD QA/QC PROCEDURES

During field operations, QC samples were collected to monitor both field and laboratory operations to evaluate the precision and accuracy of analytical data throughout the project. QC samples consisted of field duplicates and blank samples (rinsate and trip blanks).

A field duplicate soil sample was collected for every 20 samples. Field duplicates were collected randomly throughout the site and were handled and analyzed as separate samples (i.e., the field duplicate was assigned a unique sample number). These samples were not identified to the analytical laboratory as duplicates.

Rinsate blanks were collected to monitor the effectiveness of decontamination procedures and to identify the potential for cross-contamination between sampling locations. Rinsate blanks were collected by rinsing decontaminated sampling equipment with deionized water and then collecting the water in an appropriate container with required preservatives. Some rinsate blanks were analyzed for PAHs, metals, and boron. Others rinsate samples were analyzed for the full TCL parameters. Fourteen (14) rinsate blanks were collected during the Phase I Soil Investigation, including one rinsate blank each from the Tacoma City Light and Pioneer Builders Supply subsurface investigations.

Trip blanks were carried during sampling and analyzed to monitor for possible VOC contamination caused by diffusion of the organic contaminants through the polytetrafluoroethylene-faced silicone rubber septum of the sample vials during transport to and from the laboratory, as well as to monitor the quality of the laboratory water. Trip blanks were prepared by the laboratory by filling volatile organic analysis vials with deionized water and shipping the blanks with the sample

containers. Whenever a sample within a batch was to be analyzed for VOCs, a trip blank would accompany the sample jars through collection and shipment to the laboratory. Analytical results for QC samples collected during the Phase I Soil Investigation are presented in Section 7.0 of the Data Appendix, and are summarized in Table SS-4. The most common compounds detected in rinsate blanks include copper, iron, and mercury. Methylene chloride and acetone, which are common laboratory contaminants (EPA 1988d), were detected in several trip blanks and were often found in the laboratory blanks. VOC contaminants detected in the trip blanks are likely due to laboratory contamination.

Other inorganic compounds, including calcium, lead, manganese, potassium, selenium, silver, sodium, vanadium, and zinc were detected in a few samples. Lead and vanadium were detected in a sample (location number 3500) of the water used for decontamination rinsing. Phenanthrene and fluoranthene were detected in one rinsate blank, and anthracene was detected in two blanks. However, anthracene was also detected in the laboratory blanks. Bis(2-ethylhexyl)phthalate was detected in one rinsate sample and also in the laboratory blank. Rinsate results indicate that decontamination procedures were good.

3.2 LABORATORY QA/QC REVIEW

Analytical methods outlined in EPA's Contract Laboratory Program (CLP) Statements of Work (EPA 1988b; 1990a,b) were used for organic and inorganic constituents. EPA's CLP methods specify QC procedures that the laboratory is expected to meet or exceed. These procedures include analysis frequency and QC limits for laboratory method blanks, spiked samples, duplicates, and laboratory control samples. Analytical results and QC criteria were evaluated by the laboratory as part of their data reduction and documentation procedures, and in accordance with those procedures outlined in the STF QAPjP (Kennedy/Jenks/Chilton 1991c). Laboratory qualifiers were assigned to data during this review as outlined in the CLP

TABLE SS-4

SUMMARY OF FIELD RINSATE AND TRIP BLANK (QA/QC) RESULTS (µg/L)

Location Number	Blank Type	Inorganics ^(a,b)												PAHs ^(a,c)			Semivolatiles ^(a,c)	VOCs ^(a,c)	
		Calcium	Copper	Iron	Lead	Manganese	Mercury	Potassium	Selenium	Silver	Sodium	Vanadium	Zinc	Phenanthrene	Anthracene	Fluoranthene	Bis(2-ethylhexyl)-phthalate	Methylene Chloride	Acetone
3500	Rinsate	-	-	B 19.2	-	-	-	-	-	15.0	-	B 7.0	-	-	-	-	NA ^(d)	NA	NA
3500	Water ^(d)	-	-	-	B 1.4	-	-	-	-	-	-	B 6.6	-	-	-	-	NA	NA	NA
3501	Rinsate	B 72.9	-	B 9.4	-	-	0.44	-	-	-	-	-	-	-	-	-	NA	NA	NA
3502	Rinsate	-	2.0	B 89.3	-	-	N * 0.96	-	-	-	-	-	-	-	-	-	NA	NA	NA
3503	Rinsate	-	-	B 30.2	-	-	-	-	B 2.0	-	-	-	49.9	-	-	-	NA	NA	NA
3504	Rinsate	-	-	B 82.0	-	B 1.4	-	-	-	-	-	-	-	0.13	-	0.22	NA	NA	NA
3505	Rinsate	-	2.0	-	-	-	-	-	-	-	-	B 8.8	-	-	-	-	-	-	-
3508	Rinsate	-	-	B 22.6	-	-	-	B 2790	-	-	B 2640	-	-	-	-	-	NA	NA	NA
3508	Rinsate	-	1.0	B * 27.7	-	B 1.6	B 0.12	-	-	-	-	-	-	-	B 0.048	-	-	-	-
3510	Rinsate	-	4.0	B * 21.3	B N 1.2	-	-	-	-	-	B 699	-	-	-	-	-	-	-	-
3511	Rinsate	-	-	B * 19.8	-	-	B 0.37	-	B 1.1	-	-	-	-	-	B 0.058	-	NA	NA	NA
3513	Rinsate	-	-	-	-	-	-	-	-	-	-	-	-	NA	NA	NA	NA	-	-
3514	Rinsate	-	1.0	-	-	-	-	-	B 1.9	-	-	-	-	-	-	-	-	JB 6	-
3550	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3551	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3552	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3553	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3554	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3555	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10	-
3556	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9	-
3557	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10	-
3558	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 27	-
3559	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	JB 9	-
3560	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 30	-
3561	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 10	-
3562	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 33	-
3563	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 25	B 61
3564	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3565	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3566	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3567	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3568	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-

TABLE SS-4

SUMMARY OF FIELD RINSATE AND TRIP BLANK (QA/QC) RESULTS (µg/L)

Location Number	Blank Type	Inorganics ^(a,b)												PAHs ^(a,c)			Semivolatiles ^(a,c)	VOCs ^(a,c)	
		Calcium	Copper	Iron	Lead	Manganese	Mercury	Potassium	Selenium	Silver	Sodium	Vanadium	Zinc	Phenanthrene	Anthracene	Fluoranthene	Bis(2-ethylhexyl)-phthalate	Methylene Chloride	Acetone
3669	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3670	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-
3671	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 35	B 33
3672	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 30	B 29
3673	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 35	B 30
3674	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 30	B 30
3678	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	16
3679	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12	-
3800	Rinsate	-	1.0	B 45.1	-	B 1.1	-	-	B W 1.2	-	-	-	-	-	-	-	BJ 1	-	-
3810	Rinsate	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	JB 8	-
3850	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8	-
3851	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9	-
3860	Trip	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	B 15	-

- (a) Each analyte column has three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is the detected concentration; and 3) the right margin contains the data validation qualifiers.
- (b) Inorganic Data Qualifiers (also see Data Appendix):
- B - Reported value is less than EPA Contract Required Detection Limit (CRDL), but greater than, or equal to, the Instrument Detection Limit (IDL).
 - N - Spike sample recovery not within control limits.
 - * - Duplicate analysis is not within control limits.
 - - Undetected value (see Data Appendix for detection limits and associated qualifiers).
- (c) Organic Data Qualifiers (also see Data Appendix):
- B - Analyte found in associated blank as well as in sample.
 - J - Estimated value.
 - - Undetected value (see Data Appendix for detection limits and associated qualifiers).
- (d) NA = Not analyzed.

Statements of Work (EPA 1988b; 1990a,b). Laboratory-assigned data qualifiers are presented in Section 6.0 (Tables 6-1 and 6-2) of the Data Appendix.

3.3 INDEPENDENT QA/QC REVIEW OF LABORATORY DATA

Analytical data were received from the laboratory in hard-copy or magnetic format, or both. A QA review of magnetic data was performed prior to its input into the STF database. This independent review included, at a minimum, the following activities:

- Verification of sample location numbers and laboratory accession numbers
- General review to check completeness of data packages
- Comparison of 10-percent of magnetic data with hard copy data.

Data received in hard copy format only were manually entered into the STF database using a dual-entry or single-entry method, which was dependent on the quantity of data received. When data packages were dual-entered, a computer comparison program was used to check the dual-entered data for accuracy and was repeated until no discrepancies were reported (i.e., in a report of differences) between the dual-entered databases. Smaller data sets were entered into the STF database by one person and reviewed by another for errors. Once data were input into the database, a final QA review was performed.

3.4 DATA VALIDATION

Data validation of analytical results was performed to evaluate procedural compliance to QA objectives as outlined in the STF QAPjP (Kennedy/Jenks/Chilton 1991c) and to assess the laboratory's performance in meeting the QC specifications for detection limits, accuracy, precision, and completeness as outlined in the CLP Statements of Work (EPA 1988b; 1990a,b). Data validation was performed by EcoChem, Inc. (EcoChem).

Data validation was based on the criteria described in the functional guidelines for evaluating inorganic and organic analyses (EPA 1988c,d,e). Data that did not meet required criteria were flagged with validation qualifiers. Data validation qualifiers are presented in Section 6.0 (Tables 6-3 through 6-6) of the Data Appendix.

The following data validation schedule was completed for the Phase I Soil Investigation:

- 100-percent data validation for 50 percent of data packages that contain samples collected from the STF high-risk areas (i.e., BNR Dismantling Yard and Amsted).
- 100-percent data validation for 20 percent of data packages that contain samples collected from the STF medium- and low-risk areas (i.e., BNR Railyard, Former Swamp/Lakebed, Airport Area, and TIP).
- 100-percent data validation for all soil samples collected from specific areas of concern (i.e., Tacoma City Light dry wells, Pioneer Builders Supply, trash dump areas, and burn pits).

EcoChem also evaluated analytical results of field duplicate samples for semivolatile organic compounds, VOCs, PAHs, pesticides, and PCBs. Generally, duplicate concentrations exhibited high variability when compared to their associated sample

concentration. However, duplicate results for soil are expected to have high variability because of difficulties in completely homogenizing soil. Another factor in the comparability of duplicate results is that the small amount (typically 1 gram) of the sample used for analyses may not be representative of the entire sample because of the inherent variation in soil matrices. In addition, laboratory blank contamination and high concentrations of target and non-target compounds in the samples also contributes to the high variability. Despite the high variability, no validation qualifiers were assigned to any of the duplicate sample results.

Except for cyanide, EcoChem did not evaluate analytical results of inorganic field duplicates because duplicate samples were not always analyzed within the same sample delivery group. Cyanide duplicate results were judged acceptable, except for one concentration that was qualified as estimated. For other inorganic compounds, Kennedy/ Jenks Consultants calculated relative percent differences. In general, average variabilities for individual compounds were below 30 percent, except for arsenic (37 percent), copper (43 percent), and lead (42 percent). Duplicate concentrations for inorganic compounds in soil are expected to exhibit a wide variability when compared to their associated field samples for the same reasons discussed above for organic compounds.

EcoChem prepared a Data Validation Report to summarize findings for the Phase I Soil Investigation. This report is presented in Section 8.0 of the Data Appendix.

3.5 STATISTICAL ANALYSES

A statistics program was written to analyze laboratory data contained in the STF project database files. The program allows the user to select any of the finalized STF database files on the network drive and to then calculate statistics as needed. Statistics were calculated based on the following criteria:

- No QA/QC duplicate or blank analytical results were used to calculate statistics.
- Any analyte field that contained zero was not used in the statistical calculations because no data were entered in that field for that analyte.
- Any analytical result (analyte) value that contained an "R" in the data validation qualifier field was not used in the statistical calculation because the analysis produced a value that was rejected during data validation.
- All other analyte values (those without zeros or R's) were used to calculate statistics.
- All analyte values that contain "U" in either the laboratory qualifier field or data validation qualifier field were undetected values and were used in the program calculations at one-half the reported analyte value.
- All other analyte values (those without U's) were used at the reported analyte value. Where the laboratory reran an analysis because the quality control criteria were not met, both results were printed in the database. However, for statistical purposes only the "R" (rerun) or "D" (dilution) records were used to calculate statistics.

Statistics were calculated for all analytes, where appropriate, in the metals and organics STF database files. Statistical calculations are outlined below:

- The number of analyte values meeting the foregoing criteria was counted.
- The sum of selected analyte values was computed using one-half of the value where appropriate (i.e., analyte values qualified with U). In addition, the sum of the squares of the analyte values was computed for variance and standard deviation calculations.

- The maximum and minimum values were determined by a replacement algorithm. The maximum value was set to 0 and the minimum value was set to 1,000,000 at initiation of the analyte calculation pass.
- The number of values contained in various user selected class intervals (i.e., concentration ranges) was determined with a series of "IF" statements.
- The mean was calculated by dividing the sum of the analyte values by the number of values.
- The range was calculated by subtracting the minimum value from the maximum value.
- The variance was calculated by subtracting the number of values times the mean squared from the sum of the square of the values all divided by the number of values:

$$\left[\sum_{i=1 \text{ to } N} v_i^2 - (\bar{x}^2 * N) \right] / N$$

- The standard deviation was calculated by taking the square root of the variance.
- The 95-percent upper confidence limit (95% UCL) was calculated by using a two-tail T-test of the data. The T-test table for 2.5 percent values was included in the program. The T-test value was obtained by subtracting one from the number of values and indexing into the T-test array to obtain the number. For data sets greater than 31, a T-test value of 1.96 was used. The 95-percent confidence limit was calculated by adding and subtracting

the T-test value times the standard deviation divided by the square root of the number of values from the mean:

$$\bar{x} \pm [T_t * S] / \sqrt{N}$$

Statistical analyses were used to evaluate the laboratory results of surface soil samples in cases where a chemical of concern was detected in more than 5 percent of the analyzed samples. It is likely that for most inorganics, site mean concentrations used in this report are biased high because statistical calculations were calculated on a site-wide basis rather than as individual sampling units (e.g., BNR Dismantling Yard, Airport, Amsted). Relative to surface area, a proportionately larger number of samples were collected from areas where the highest concentrations were anticipated (based on limited existing sampling data and knowledge of historical activities) in an effort to better characterize the nature and extent of potential contamination.

Subsurface data from the Tacoma City Light and Pioneer Builders Supply investigations were not statistically analyzed because sample locations were targeted in areas suspected of high concentrations. Statistical analyses of analytical results from a small number of sampling locations would likely exhibit higher concentrations than might actually exist in subsurface soil throughout the site.

3.6 DATABASE REPORT PRINTOUTS

Database files were formatted and printed as database reports on 14.5x11-inch paper. This size was selected because it allowed a 75-percent reduction to fit 8.5x11-inch paper. The format and reduction maintains data that are easily readable, allows printing 53 lines of data per sheet, and significantly reduces the

size of the Data Appendices. The database report printouts (analytical results) are presented in Section 7.0 of the Data Appendix.

Two lines of data from the report header are printed at the bottom of all database reports to make paging through the reports easier. This footer indicates the database filename, date and time that file was last revised, file size, date printed, and page number.

The database report has a separate but complementary location number report (see Section 3.0 of the Data Appendix) that includes all location, survey, and sampling information [i.e., EPA Storet code, STF location number, laboratory number, NAD coordinate (northing and easting) data, and elevation].

Special report printing programs were also written to print nonstandard reports that contain ancillary information (separate from analytical data) and retain a format comparable to the database reports. These reports contain results from geotechnical testing and field data (e.g., field observations during sample collection).

4.0 INVESTIGATIVE RESULTS

Laboratory analytical and testing results for the chemical and supplemental characterization analyses of soil samples collected for the Phase I Soil Investigation are discussed in this section. Laboratory results are presented on a site-wide basis and are organized into the following four sections:

- Inorganic compounds - Metals, metalloids (antimony, arsenic, and boron), and nonmetals (selenium and cyanide)
- Organic compounds - PAHs, VOCs, and semivolatile organic compounds, pesticides/PCBs, and dioxins and furans
- Supplemental parameters - Permeability/hydraulic conductivity, particle size distribution, porosity-specific gravity, in-situ density and moisture, compaction, Atterberg limits, moisture, and total organic carbon
- Field observations - Sampling data and other relevant information.

Statistical analyses were used to evaluate the laboratory results of surface soil samples in cases where a chemical of concern was detected in more than 5 percent of the analyzed samples. The criteria used to calculate statistical values for each analyte that was evaluated are discussed in Section 3.5. It is likely that for most inorganics, the site mean concentrations used in this report are biased high because statistical calculations were computed on a site-wide basis rather than as individual sampling units (e.g., BNR Dismantling Yard, Airport, Amsted). Relative to surface area, a proportionately larger number of samples were collected from areas where the highest concentrations were anticipated (based on limited existing sampling data and knowledge of historical activities) in an effort to better characterize the nature and extent of potential contamination.

It is likely that it will be most appropriate to treat the sampling units individually during the risk assessment and feasibility study. Data collected and evaluated during this investigation are intended to provide the technical support for defining operable units. In the absence of site-wide characterization, the determination to discuss analytical results on an operable unit basis was not justified prior to completion of this investigation.

Subsurface data from the Tacoma City Light and Pioneer Builders Supply investigations were not statistically analyzed because sample locations were targeted in areas suspected of high concentrations. Statistical analyses of analytical results from a small number of sampling locations would likely exhibit higher concentrations than might actually exist in subsurface soil throughout the site.

For most inorganics analyzed for the Phase I Soil Investigation, five concentration ranges or class intervals were determined for each chemical of concern to group the analytical results. The number of analytical values detected within each class interval is presented in the statistical summary tables generated for each chemical of concern. Data were typically sorted into five class intervals (although in some cases the number of intervals was different than five) to facilitate the graphical representation of data based on cumulative probability analysis.

Cumulative probability analyses plot normally distributed data as a straight line, and two or more normally distributed populations within a data set are expressed as two or more straight line segments (Johnson 1991). Probability plots are well recognized in mineral exploration as a method of distinguishing background concentrations from elevated concentrations (Sinclair 1976; Kock and Link 1980).

For some inorganics, the cumulative probability plots of analytical results exhibited a greater number of intervals than could be practically shown in a single map presentation format. In these cases, best professional judgment was used to combine two or more intervals to present the data for visual interpretation. For

example, the intervals 0 mg/kg-7 mg/kg and greater than 7 mg/kg-11 mg/kg would be grouped into one interval: 0 mg/kg-11 mg/kg.

Concentrations ranging more than 1 order of magnitude greater than the highest interval value (as determined from the cumulative probability analysis) were shown as an additional interval to highlight the locations of the most elevated concentrations. For example, a cumulative probability analysis resulted in the last interval including all concentrations > 20 mg/kg for a particular chemical of concern. However, three concentration values were above 200 mg/kg. These three concentrations were then grouped into another interval (all values > 200 mg/kg) and graphically displayed.

The cumulative probability analyses for some inorganics displayed only two, three, or four clearly defined class intervals. The number of intervals for graphical presentation was reduced accordingly.

Class intervals for organic compounds were arbitrarily selected, albeit based on best professional judgement, so as to visually present information in a comprehensible form as well as to depict the location of the highest detected concentrations for each chemical of concern. Class intervals for organic compounds were selected to include a fixed percentage of the reported concentrations as shown below:

Class Interval	Percent of Detected Concentrations	Range of Detected Concentrations (Percent)
1	Undetected Values	—
2	50	0 - 50
3	30	50 - 80
4	15	80 - 95
5	5	95 - 100

The first class interval contains all undetected values. For the remaining intervals, the detected concentrations were arranged in ascending order. The second class interval contains the lowest half of all detected concentrations. The third interval contains 30 percent of the next highest detected concentrations (i.e., the lowest 80 percent of all detected concentrations minus the 50 percent of detected values in the first class interval). The fourth interval contains 15 percent of the next highest detected concentrations (the lowest 95 percent of all detected concentrations minus the values in the second and third intervals). The last class interval contains the highest 5 percent of all detected concentrations.

The actual percentages for each class interval could differ slightly from these if the total number of detected values was small. When the total number of detected values was small, the number of values grouped into an interval could result in a percentage that was slightly greater than or less than the target percentage.

Concentrations of chemicals of concern detected in surface soil samples are presented graphically in instances when the chemical of concern was detected in 5 percent or more of the samples analyzed. Graphical presentations of chemicals of concern are available in distribution figures and in concentration maps in the Reference Appendix.

Because samples collected in the BNR Dismantling Yard and Amsted were composite samples, chemical concentrations displayed on the maps are good representations of conditions within a given location. However, in the other sampling units, samples were collected from the location (grid) nodes and do not necessarily represent conditions throughout the location as accurately; therefore, graphical representations in these areas are approximate.

For the purposes of graphical presentation, the location pattern overlay for the Airport, Former Swamp/Lakebed, TIP, and the BNR Railyard was shifted to the south and east so that the actual sampling point appears to be in the center. This

was done to facilitate graphical presentations. Exact sampling locations are presented in Section 3.0 of the Data Appendix.

4.1 INORGANICS

This section presents analytical data for the inorganic compounds for samples collected from background (Section 4.1.1) and onsite (Section 4.1.2) locations. A summary of these results for the six onsite sampling units is presented in Section 4.1.3. In addition, summaries of analytical results for the preliminary subsurface investigations at Tacoma City Light and Pioneer Builders Supply are presented in Sections 4.1.4 and 4.1.5, respectively.

4.1.1 Background Surface Soil Concentrations

Inorganic analytical results and the corresponding statistical summary of the background surface soil samples collected during the Phase I Soil Investigation are presented in Table SS-5. Eleven (11) samples were analyzed for inorganics (the inorganic analytical schedule is summarized in Section 2.3.1). Sample locations are described in Table SS-1 and shown in Figure SS-4 (see Section 2.1).

Hexavalent chromium, selenium, silver, thallium, and cyanide were not detected in any of the background samples. Antimony, beryllium, cadmium, and mercury were undetected in most samples. In samples that exhibited a detectable concentration of antimony, beryllium, and cadmium, all reported concentrations were assigned a B concentration qualifier [i.e., the reported concentration was less than the EPA Contract Required Detection Limit (CRDL), but greater than, or equal to, the instrument detection limit (IDL)]. The B qualifier indicates a trace concentration slightly above detection levels. All detected concentrations of cobalt, potassium, and sodium were similarly qualified.

TABLE SS-5

SUMMARY OF INORGANIC ANALYTICAL RESULTS (mg/kg)
AND STATISTICAL RESULTS FOR BACKGROUND SURFACE SOIL SAMPLES

Chemical	Sample Location Concentrations ^(a,b,c)											Minimum Concentration	Maximum Concentration	Mean Concentration	Variance (mg/kg) ²	Standard Deviation	Upper 95% Confidence Interval	Content in Soil ^(d)	
	961	962	963	964	965	966	967	968	969	970	971							Selected Average Soil Concentrations	Common Concentration Range for Soil
Aluminum	11,000	16,100	9,600	11,900	13,000	13,900	12,600	21,900	8,920	9,740	11,700	8,920	21,900	12,800	12,300,000	3,500	16,100	71,000	10,000 - 300,000
Antimony	B 6.7	—	B 6.6	—	—	—	—	—	—	B 6.8	—	2.2	6.8	3.2	2.3	1.6	4.2	NA ^(d)	NA
Arsenic	—	NS 12.6	N 3.8	N 4.8	N 6.9	N 6.6	N 5.3	NS 6.8	—	N 5.3	—	1.3	12.6	6.0	9.6	3.1	7.1	5	1-50
Barium	46.2	161	48.7	86.7	94.2	73.7	64.1	124	46.9	64.4	47.7	46.2	161	78.8	1270	36.6	101	430	100 - 3,000
Beryllium	—	B 0.31	—	B 0.28	B 0.23	—	—	B 0.46	—	—	—	0.11	0.46	0.19	0.01	0.11	0.26	6	0.1 - 40
Cadmium	—	B 0.94	—	—	B 0.99	—	—	B 0.74	—	—	—	0.22	0.99	0.40	0.09	0.30	0.61	0.08	0.01 - 0.7
Calcium	3,240	2,960	2,990	3,230	3,660	2,970	2,980	4,400	1,990	3,600	3,670	1,990	4,400	3,220	314,000	661	3,680	13,700	7,000 - 600,000
Chromium Total	18.2	23.7	19.1	26.6	30.2	17.7	24.4	26.6	16.2	21.6	23.2	16.2	30.2	22.6	17.3	4.2	26.3	100	1 - 1,000
Cobalt	B 6.1	B 7.1	B 6.2	B 6.6	B 6.6	B 6.3	B 7.4	B 7.8	B 4.8	B 6.3	B 6.6	4.8	7.8	6.3	0.81	0.90	6.9	8	1 - 40
Copper	E 10.3	E 27.6	E 14.2	E 23.4	E 32.4	E 13.0	E 19.1	E 34.0	E 12.7	E 13.8	E 9.6	9.6	34.0	19.1	71.6	8.6	24.8	30	2 - 100
Iron	11,400	16,100	12,800	13,600	16,700	10,900	13,700	16,700	10,400	13,800	12,900	10,400	16,700	13,400	3,660,000	1,890	14,600	38,000	7,000 - 660,000
Lead	S 3.1 J4	N 83.7 J4	68.7 J4	S 24.2 J4	N 166 J4	S 42.6 J4	S 26.0 J4	N 87.8 J4	S 12.2 J4	S 41.0 J4	S 4.4 J4	3.1	166	49.8	1,920	43.8	79.2	10	2 - 200
Magnesium	3,090	3,790	4,270	4,400	4,380	3,300	4,690	4,660	3,440	4,440	3,890	3,090	4,690	4,030	287,000	636	4,390	6,000	600 - 6,000
Manganese	222	634	268	236	271	287	286	600	197	249	241	197	634	316	20,800	144	413	600	20 - 3,000
Mercury	—	0.13	—	—	0.24	—	—	—	—	—	—	0.010	0.24	0.064	0.0046	0.067	0.10	0.03	0.01 - 0.3
Nickel	22.7	28.4	26.3	32.8	37.2	21.9	32.0	29.3	28.0	29.0	23.4	21.9	37.2	28.2	20.0	4.6	31.2	40	6 - 600
Potassium	B 386	B 389	B 724	B 667	B 600	B 464	B 711	B 482	B 414	B 609	B 411	386	724	603	12,800	113	679	8,300	400 - 30,000
Sodium	B 110	—	B 131	B 99.3	B 96.6	B 77.6	B 131	B 113	B 77.2	B 147	B 127	28.0	147	103	1,020	32.0	126	6,300	760 - 7,600
Vanadium	28.2	32.3	26.4	31.3	33.1	27.2	29.6	36.8	21.8	29.1	30.3	21.8	36.8	29.6	12.8	3.6	32.0	100	20 - 600
Zinc	64.6	97.2	76.1	80.6	136	66.6	49.2	129	26.4	38.7	27.9	26.4	136	70.9	1,260	36.6	94.8	60	10 - 300

- (a) Each sample location column has three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is the reported concentration; and 3) the right margin contains the data valuation qualifiers.
- (b) Inorganic Data Qualifiers (also see Data Appendix):
B - Reported value is less than the EPA Contract Required Detection Limit (CRDL), but greater than, or equal to, the Instrument Detection Limit (IDL).
N - Spike sample recovery not within control limits.
S - Reported value was determined by Method of Standard Additions.
E - Reported value is estimated because of interference.
J4 - Estimated value. Other QC outside control limits; bias not readily determined.
- (c) — - Undetected value (see Data Appendix for detection limits and associated qualifiers).
- (d) Source: Lindsay (1979).
- (e) NA - Not available.

Arsenic, copper, and lead were detected in most samples. However, all detected arsenic and three lead concentrations resulted from analyses where laboratory QC samples did not meet spike recovery criteria. All copper concentrations were estimated. Barium, trivalent and total chromium, manganese, nickel, vanadium, zinc, aluminum, calcium, iron, and magnesium were detected in every background sample.

In Table SS-5, average soil concentrations and an average range of concentration values for soil (Lindsay 1979) are presented for comparison to detected background concentrations. The detected mean background concentration in the STF vicinity for cadmium was approximately seven times higher than the average soil concentration. The mean background concentrations for beryllium, sodium, and potassium were significantly lower (by more than 1 order of magnitude) than the average soil concentrations for these same constituents. Other mean background concentrations for inorganics approximated the average soil concentrations.

4.1.2 Onsite Surface Soil Concentrations

Five-hundred ninety (590) samples (excluding duplicates and blanks) were analyzed for inorganics. Distribution figures and concentration maps of the inorganic analytical results are available in the Reference Appendix. Complete analytical results, including laboratory and validation qualifiers, are presented Section 7.0 of the Data Appendix. Inorganics were organized alphabetically for discussion.

For each inorganic discussed, a summary of the statistical results (excluding duplicates and blanks) and the number of values (detected and undetected) within each class interval are presented in the following subsections. A brief description of the graphical presentation of each inorganic compound is also included. The terms low, moderate, and high, when referring to site concentrations, are used relative to concentrations reported in other samples collected from the STF site.

When five class intervals are shown on a distribution figure, low refers to the first and second class intervals; moderate refers to the third class interval; and high refers to the fourth and fifth class intervals. When six class intervals are presented, two intervals are grouped into each designation (i.e., two intervals each in the low, moderate, and high designation categories). When four intervals (including distribution figures for organic compounds) are presented, the first two intervals are described as low, the third is categorized as moderate, and the last class interval is deemed high. When three intervals are presented, the first class interval is called low, the second moderate, and the third high.

Aluminum. Aluminum was detected in 590 samples (100%). The statistical summary for all analyzed samples is presented in Table SS-6, and the graphical presentations are shown in Figure 1 and Map 1 in the Reference Appendix.

TABLE SS-6
STATISTICAL SUMMARY FOR ALUMINUM

Number of Values	Minimum Concentration (mg/kg) ^(a)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	1,350	104,000	13,600	34,600,000	5,880	14,100
Number of Values Per Class Interval						
0 - <7,700	7,700 - <11,800	11,800 - <19,000	19,000 - <24,000	≥ 24,000		
35	194	304	42	15		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected primarily in samples collected from locations throughout the BNR Railyard and the Former Swamp/Lakebed. Moderate concentrations were detected throughout all sampling units. High concentrations were detected in samples collected primarily from the BNR Dismantling Yard, and a few locations in the Airport, Amsted, and BNR Railyard. The maximum aluminum concentration, 104,000 mg/kg, was detected in the sample collected from location 377 in the BNR Dismantling Yard.

The mean aluminum concentration at STF was below the area background concentration of 15,100 mg/kg (95% UCL) and well within the common range for soil.

Antimony. Antimony was detected in 270 samples (57%). The statistical summary for all analyzed samples is presented in Table SS-7, and the graphical presentations are shown in Figure 2 and Map 2 in the Reference Appendix.

TABLE SS-7
STATISTICAL SUMMARY FOR ANTIMONY

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
471	2.0	491	11.3	809	28.4	13.8
Number of Values Per Class Interval (mg/kg)						
0 - <6.3	6.3 - <7.5	7.5 - <10.0	10.0 - <20.0	≥20.0		
226	29	50	120	46		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were generally detected in samples collected from the Former Swamp/Lakebed and Airport. Moderate concentrations were detected in samples collected from the BNR Dismantling Yard, BNR Railyard, sections in Amsted, and from a few locations the Airport, Swamp/Lakebed, and TIP. High concentrations were detected in samples from the BNR Dismantling Yard, the central and southern sections of the BNR Railyard, primarily the northern section in Amsted, two locations in TIP, and from the northeastern section (adjacent to the BNR Dismantling Yard and BNR Railyard) of the Airport. The maximum antimony concentration, 491 mg/kg, was detected in the sample collected from location 911 in the BNR Railyard.

The mean antimony concentration at STF was above the area background concentration of 4.2 mg/kg (95% UCL). Lindsay (1979) did not provide a range or average concentration for antimony commonly detected in soil.

Arsenic. Arsenic was detected in 570 samples (97%). The statistical summary for all analyzed samples is presented Table SS-8, and the graphical presentations are shown in Figure 3 and Map 3 in the Reference Appendix.

TABLE SS-8
STATISTICAL SUMMARY FOR ARSENIC

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
577	0.24	696	31.1	2,080	45.6	34.8
Number of Values Per Class Interval						
0 - <20.0	20.0 - <55.0	55.0 - <73.0	73.0 - <170	≥ 170		
274	239	32	27	5		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from all sampling units, but particularly the Former Swamp/Lakebed, TIP, and the Airport. Moderate concentrations were generally detected in the samples collected from the BNR Dismantling Yard and the BNR Railyard. High concentrations were detected mainly in samples collected from the BNR Dismantling Yard, the central section of the BNR Railyard, and the southern portion of Amsted. The maximum arsenic concentration, 696 mg/kg, was detected in the sample collected from location 547 in the BNR Dismantling Yard.

The mean arsenic concentration at STF was above the area background concentration of 7.1 (95% UCL), but within the common range for soil.

Barium. Barium was detected in 590 samples (100%). The statistical summary for all analyzed samples is presented in Table SS-9, and the graphical presentations are shown in Figure 4 and Map 4 in the Reference Appendix.

TABLE SS-9
STATISTICAL SUMMARY FOR BARIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	9.9	2,600	264	75,700	275	286
Number of Values Per Class Interval						
0 - <85.0	85.0 - <270	270 - <570	570 - <1,500	≥ 1,500		
106	305	125	49	5		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from all sampling units, particularly the western portion of the Airport and the southern section of the Former Swamp/Lakebed (except the southern boundary). Moderate concentrations were detected in samples collected from several locations in the BNR Dismantling Yard [eastern area (two adjacent locations) of the Airport adjacent to the BNR Railway], the northern end and central and southern sections of the BNR Railway, the northern section of the Former Swamp/Lakebed, and from a few locations in Amsted. High concentrations were detected in samples collected from the BNR Dismantling Yard, particularly in the western section, several locations in the BNR Railway, and along the southern border of the Former Swamp/Lakebed. The maximum barium concentration, 2,600 mg/kg, was detected in the sample collected from location 414 in the BNR Dismantling Yard.

The mean barium concentration at STF was above the area background concentration of 101 mg/kg (95% UCL), but well within the common range for soil.

Beryllium. Beryllium was detected in 475 samples (81%). The statistical summary for all analyzed samples is presented in Table SS-10, and the graphical presentations are shown in Figure 5 and Map 5 in the Reference Appendix.

TABLE SS-10
STATISTICAL SUMMARY FOR BERYLLIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	0.09	14.4	0.98	1.1	1.0	1.1
Number of Values Per Class Interval						
0 - <0.35	0.35 - <0.60	0.60 - <3.7	≥3.7			
178	109	295	8			

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, low concentrations were detected in samples collected from all sampling units, except the BNR Dismantling Yard and Amsted. Moderate concentrations were detected in samples collected from the BNR Dismantling Yard, BNR Railyard, Amsted, and the southern section of the Former Swamp/Lakebed. Except for one group of three locations, the highest concentrations were detected in samples collected from scattered locations in the BNR Dismantling Yard. The maximum beryllium concentration, 14.4 mg/kg, was detected in the sample collected from location 547 in the BNR Dismantling Yard.

The mean beryllium concentration at STF was above the background concentration of 0.26 mg/kg (95% UCL), but well within the common range for soil.

Boron. Boron was detected in 107 samples (20%). The statistical summary for all analyzed samples is presented in Table SS-11, and the graphical presentations are shown in Figure 6 and Map 6 in the Reference Appendix.

TABLE SS-11
STATISTICAL SUMMARY FOR BORON

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
542	0.75	1,300	9.5	3,430	58.6	14.4
Number of Values Per Class Interval						
0 - <6.0	6.0 - <13.0	13.0 - <48.0	48.0 - <150	≥ 150		
441	37	43	18	3		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from all sampling units. Moderate concentrations were detected in samples collected from the northern edge of the BNR Dismantling Yard, the central portion of the BNR Railyard, and the eastern edge of the Airport. High concentrations were detected in samples collected from the northern boundary of the BNR Dismantling Yard and the northwestern section and other scattered locations in the BNR Railyard. The maximum boron concentration, 1,300 mg/kg, was detected in the sample collected from location 414 in the BNR Dismantling Yard.

No comparison with area background concentrations can be made for boron because background samples were not analyzed for boron.

Cadmium. Cadmium was detected in 460 samples (78%). The statistical summary for all analyzed samples is presented in Table SS-12, and the graphical presentations are shown in Figure 7 and Map 7 in the Reference Appendix.

TABLE SS-12
STATISTICAL SUMMARY FOR CADMIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	0.11	29.9	2.9	15.0	3.9	3.2
Number of Values Per Class Interval						
0 - <0.60	0.6 - <2.9	2.9 - <4.5	4.5 - <14.0	≥ 14.0		
156	251	65	106	12		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from all the sampling units particularly TIP, the western portion of the Airport, and the Former Swamp/Lakebed. Moderate concentrations were detected primarily in samples collected from the eastern half of the BNR Dismantling Yard, and from a few locations (mostly scattered) in the BNR Railyard and Airport. High concentrations were detected in samples collected from locations throughout the BNR Dismantling Yard, the central portion of the BNR Railyard, and the north-central section of Amsted. The maximum cadmium concentration, 29.9 mg/kg, was detected in the sample collected from location 426 in the BNR Dismantling Yard.

The mean cadmium concentration at STF was above the area background concentration of 0.61 mg/kg (95% UCL) and above the common range for soil.

Calcium. Calcium was detected in 589 samples (100%). The statistical summary for all analyzed samples is presented in Table SS-13, and the graphical presentations are shown in Figure 8 and Map 8 in the Reference Appendix.

TABLE SS-13
STATISTICAL SUMMARY FOR CALCIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	245	323,000	7,840	451,000,000	21,200	9,550
Number of Values Per Class Interval						
0 - <2,600	2,600 - <4,750	4,750 - <7,400	7,400 - <11,300	≥ 11,300		
41	242	171	83	53		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations of calcium were detected in samples collected from the western portion of the Airport, the BNR Dismantling Yard, most of the Former Swamp/Lakebed, and portions of Amsted and TIP. Moderate concentrations were detected in samples collected from all sampling units, but particularly from the BNR Dismantling Yard, the BNR Railyard, Amsted, and the eastern portion of the Airport. High concentrations were detected in samples collected from all sampling units, particularly the BNR Dismantling Yard and the BNR Railyard. The maximum calcium concentration, 323,000 mg/kg, was detected in the sample collected from location 912 in the BNR Railyard.

The mean calcium concentration at STF was above the area background concentration of 3,590 mg/kg (95% UCL), but well within the common range for soil.

Chromium. Chromium (total) was detected in 589 samples (approximately 100%). The statistical summary for all analyzed samples is presented in Table SS-14, and the graphical presentations are shown in Figure 9 and Map 9 in the Reference Appendix.

TABLE SS-14
STATISTICAL SUMMARY FOR CHROMIUM (TOTAL)

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	2.9	707	53.7	3,570	59.8	58.6
Number of Values Per Class Interval						
0 - <24.0	24.0 - <36.0	36.0 - <55.0	55.0 - <135	≥ 135		
135	178	120	122	35		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from the BNR Railway, TIP, the Airport, and portions of Amsted. Moderate concentrations were detected mainly in samples collected from the eastern two-thirds of the BNR Dismantling Yard, the central portion of the BNR Railway, portions of Amsted and the Former Swamp/Lakebed area. High concentrations were detected in samples collected from locations throughout the BNR Dismantling Yard, sections of the central portion of the BNR Railway, the northern section of the Airport adjacent to the BNR Dismantling Yard and BNR Railway, a large portion of the Former Swamp/Lakebed, and the central section of Amsted. The maximum chromium (total) concentration, 707 mg/kg, was detected in the sample collected from location 399 in the BNR Dismantling Yard.

The mean chromium (total) concentration at STF was above the area background concentration of 25.3 mg/kg (95% UCL), but well within the common range for soil.

Cobalt. Cobalt was detected in 564 samples (96%). The statistical summary for all analyzed samples is presented in Table SS-15, and the graphical presentations are shown in Figure 10 and Map 10 in the Reference Appendix.

TABLE SS-15
STATISTICAL SUMMARY FOR COBALT

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	0.70	135	11.4	53.0	7.3	12.0
Number of Values Per Class Interval						
0 - <8.3		8.3 - <15.0		15.0 - <22.0		≥22.0
192		292		81		25

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from all sampling units, particularly the Airport, the Former Swamp/Lakebed, the BNR Railyard, and Amsted. Moderate concentrations were detected in samples collected from the northern and western sections of the BNR Dismantling Yard, and locations in the central and southern portions of the BNR Railyard. High concentrations were detected in samples collected from the BNR Dismantling Yard and from a few locations in the BNR Railyard. The maximum cobalt concentration, 135 mg/kg, was detected in the sample collected from location 547 in the BNR Dismantling Yard.

The mean cobalt concentration at STF was above the area background concentration of 6.9 mg/kg (95% UCL), but within the common range for soil.

Copper. Copper was detected in 585 samples (99%). The statistical summary for all analyzed samples is presented in Table SS-16, and the graphical presentations are shown in Figure 11 and Map 11 in the Reference Appendix.

TABLE SS-16
STATISTICAL SUMMARY FOR COPPER

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	7.2	163,000	1,420	94,400,000	9720	2210
Number of Values Per Class Interval						
0 - <245	245 - <460	460 - <1,000	1,000 - <3,000	3,000 - <13,000	≥ 13,000	
368	92	65	36	22	7	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from all sampling units. Moderate concentrations were detected in samples collected from locations throughout the BNR Dismantling Yard, and the central and southern sections of the BNR Railyard. High concentrations were detected in samples collected from the north-central section of Amsted, and from scattered locations in the BNR Dismantling Yard and the BNR Railyard. Particularly high concentrations of copper were detected in some of the samples collected from Amsted. The maximum copper concentration, 163,000 mg/kg, was detected in the sample collected from location 846 in Amsted.

The mean copper concentration at STF was higher than the area background concentration of 24.8 mg/kg (95% UCL) and above the common range for soil.

Cyanide. Because analytical results for cyanide were not amenable to cumulative probability analysis, determination of class intervals was not performed. The statistical summary is presented in Table SS-17, and the graphical presentations are shown in Figure 12 and Map 12 in the Reference Appendix.

TABLE SS-17
STATISTICAL SUMMARY FOR CYANIDE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
123	0.25	2.3	0.40	0.12	0.35	0.46

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Because cyanide is a TCL substance, only 20 percent of the samples collected were analyzed. Cyanide was detected in only 18 samples (15%) collected from the STF site. Cyanide was not detected in samples collected from TIP, the Former Swamp/Lakebed, or Amsted. Cyanide was detected in only two samples collected from locations in the Airport. Cyanide was primarily detected in samples collected from scattered locations in the BNR Dismantling Yard and from the central and southern portions of the BNR Railyard. The maximum cyanide concentration, 2.3 mg/kg, was detected in the sample collected from location 682 in the BNR Railyard.

The mean cyanide concentration at STF cannot be compared to background concentrations because cyanide was not detected in samples collected offsite.

Iron. Iron was detected in 590 samples (100%). The statistical summary for all analyzed samples is presented in Table SS-18, and the graphical presentations are shown in Figure 13 and Map 13 in the Reference Appendix.

TABLE SS-18
STATISTICAL SUMMARY FOR IRON

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	135	298,000	57,400	2.51×10^9	50,100	61,400
Number of Values Per Class Interval						
0 - <20,000		20,000 - <53,000	53,000 - <130,000	$\geq 130,000$		
151		219	160	60		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from the Airport, the Former Swamp/Lakebed, TIP, and most of the BNR Railyard. Moderate concentrations were detected in samples collected from most locations in the BNR Dismantling Yard, small groupings of locations in the BNR Railyard, and in Amsted. High concentrations were detected in samples collected from the storage yard area (see legend number 10 in Figure SS-1) in the BNR Dismantling Yard, and a few locations within the BNR Railyard, and Amsted. The maximum iron concentration, 298,000 mg/kg, was detected in the sample collected from location 465 in the BNR Dismantling Yard.

The mean iron concentration at STF was above the area background concentration of 14,600 mg/kg (95% UCL), but well within the common range for soil.

Lead. Lead was detected in 585 samples (99%). The statistical summary for all analyzed samples is presented in Table SS-19, and the graphical presentations are shown in Figure 14 and Map 14 in the Reference Appendix.

TABLE SS-19
STATISTICAL SUMMARY FOR LEAD

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	5.3	118,000	2,100	54,200,000	7,360	2,690
Number of Values Per Class Interval						
0 - <200	200 - <610	610 - <1,600	1,600 - <2,700	2,700 - <10,000	≥10,000	
183	158	117	50	62	20	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from the Former Swamp/Lakebed, the Airport, TIP, and the BNR Railyard. Moderate concentrations were detected in samples collected from the BNR Dismantling Yard and the BNR Railyard. High concentrations were detected in samples collected primarily from the western half of the BNR Dismantling Yard, scattered locations in the BNR Railyard, and particularly from the north-central section of Amsted. The maximum lead concentration, 118,000 mg/kg, was detected in the sample collected from location 838 in Amsted.

The mean lead concentration at STF was above the area background concentration of 79.2 (95% UCL) and above the common range for soil.

Magnesium. Magnesium was detected in 590 samples (100%). The statistical summary for all analyzed samples is presented in Table SS-20, and the graphical presentations are shown in Figure 15 and Map 15 in the Reference Appendix.

TABLE SS-20
STATISTICAL SUMMARY FOR MAGNESIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	251	25,700	3,710	4,220,000	2,050	3,880
Number of Values Per Class Interval						
0 - <1,900		1,900 - <5,400		5,400 - <20,000		≥20,000
33		530		23		4

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Magnesium was detected at moderate to low concentrations in samples collected from locations throughout the entire site. The highest concentrations were detected in samples collected from the Former Swamp/Lakebed in the general area of the disposal sites (see Figure SS-1). The maximum magnesium concentration, 25,700 mg/kg, was detected in the sample collected from location 785 in the Former Swamp/Lakebed.

The mean magnesium concentration at STF was below the area background concentration of 4,390 mg/kg (95% UCL) and within the common range for soil.

Manganese. Manganese was detected in 590 samples (100%). The statistical summary for all analyzed samples is presented in Table SS-21, and the graphical presentations are shown in Figure 16 and Map 16 in the Reference Appendix.

TABLE SS-21

STATISTICAL SUMMARY FOR MANGANESE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	22.7	21,800	784	1,530,000	1,240	884
Number of Values Per Class Interval						
0 - <290	290 - <525	525 - <880	880 - <2,000	≥2,000		
72	242	151	96	29		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from locations throughout the Airport, the BNR Railyard, and the south-central section (except along the southern border) of the Former Swamp/Lakebed. Moderate concentrations were detected in samples collected from locations throughout the BNR Dismantling Yard, primarily the central section of the BNR Railyard, scattered locations in the Airport, and the north-central portion of the Former Swamp/Lakebed. High concentrations were detected in samples collected from locations in the BNR Dismantling Yard, scattered locations throughout the BNR Railyard, the north-central and southern boundary of the Former Swamp/Lakebed, the central portion of TIP, and most of Amsted. The maximum manganese concentration, 21,800 mg/kg, was detected in the sample collected from location 836 in Amsted.

The mean manganese concentration at STF was above the area background concentration of 413 mg/kg (95% UCL), but well within the common range for soil.

Mercury. Mercury was detected in 462 samples (78%). The statistical summary for all analyzed samples is presented in Table SS-22, and the graphical presentations are shown in Figure 17 and Map 17 in the Reference Appendix.

TABLE SS-22
STATISTICAL SUMMARY FOR MERCURY

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	0.036	5.3	0.25	0.24	0.49	0.29
Number of Values Per Class Interval						
0 - <0.060	0.060 - <0.14	0.14 - <0.36	0.36 - <0.80	≥0.80		
181	121	195	67	26		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from all sampling units but primarily from TIP, most of the Airport, and the Former Swamp/Lakebed. Moderate concentrations were detected in samples collected from locations throughout the BNR Dismantling Yard and BNR Railyard, the eastern edge of the Airport adjacent to the BNR Railyard, and the southern section of Amsted. High concentrations were detected in samples collected from several locations in the BNR Dismantling Yard, the BNR Railyard, and the north-central section of Amsted. The maximum mercury concentration, 5.3 mg/kg, was detected in the sample collected from location 538 in the BNR Dismantling Yard.

The mean mercury concentration at STF was above the area background concentration of 0.10 mg/kg (95% UCL) and within the common range for soil.

Nickel. Nickel was detected in 585 samples (99%). The statistical summary for all analyzed samples is presented in Table SS-23, and the graphical presentations are shown in Figure 18 and Map 18 in the Reference Appendix.

TABLE SS-23
STATISTICAL SUMMARY FOR NICKEL

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	2.8	865	47.6	3,080	55.5	52.1
Number of Values Per Class Interval						
0 - <28.0	28.0 - <40.0	40.0 - <85.0	85.0 - <200	≥ 200		
149	216	184	32	9		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were generally detected in samples collected from the Airport, the BNR Railyard, TIP, and the southern section of the Former Swamp/Lakebed. Moderate concentrations were detected in samples collected from locations throughout the BNR Dismantling Yard, BNR Railyard, Former Swamp/Lakebed, Amsted, and from a few locations in the Airport. High concentrations were detected in samples collected from the central portion of Amsted, the north-central section of the Former Swamp/Lakebed, and from a few locations in the BNR Dismantling Yard and the BNR Railyard. The maximum nickel concentration, 865 mg/kg, was detected in the sample collected from location 855 in Amsted.

The mean nickel concentration at STF was above the area background concentration of 31.2 mg/kg (95% UCL), but well within the common range for soil.

Potassium. Potassium was detected in 529 samples (90%). The statistical summary for all analyzed samples is presented in Table SS-24, and the graphical presentations are shown in Figure 19 and Map 19 in the Reference Appendix.

TABLE SS-24
STATISTICAL SUMMARY FOR POTASSIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	48.6	6,190	562	122,000	350.0	590.0
Number of Values Per Class Interval						
0 - <360		360 - <825	825 - <1,250	≥ 1,250		
112		418	47	13		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Potassium was detected at moderate to low concentrations in samples collected from locations throughout the site. The highest concentrations were detected in samples collected from isolated areas in the BNR Dismantling Yard, scattered locations in the BNR Railyard, and one sampling location each in the Former Swamp/Lakebed and Amsted. The maximum potassium concentration, 6,190 mg/kg, was detected in the sample collected from location 734 in the Former Swamp/Lakebed.

The mean potassium concentration at STF is similar to the area background concentration of 579 mg/kg (95% UCL) and well within the common range for soil.

Selenium. Selenium was detected in 120 samples (22%). The statistical summary for all analyzed samples is presented in Table SS-25, and the graphical presentations are shown in Figure 20 and Map 20 in the Reference Appendix.

TABLE SS-25
STATISTICAL SUMMARY FOR SELENIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
555	0.05	141	0.72	40.9	6.4	1.2
Number of Values Per Class Interval						
0 - <0.50	0.50 - <0.72	0.72 - <0.80	0.80 - <10.0	≥10.0		
490	31	6	25	3		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, low concentrations were detected in samples collected from locations throughout the site. Moderate concentrations were detected in a few samples collected from the BNR Dismantling Yard, the BNR Railyard, and the Airport. High concentrations were detected in two adjacent locations in the central section of Amsted, from a few locations in the BNR Dismantling Yard, the BNR Railyard, the Former Swamp/Lakebed, and one location in TIP. The maximum selenium concentration, 141 mg/kg, was detected in the sample collected from location 311 in the BNR Dismantling Yard.

The mean selenium concentration at STF cannot be compared to background concentrations because selenium was not detected in samples collected offsite.

Silver. Silver was detected in 86 samples (15%). The statistical summary for all analyzed samples is presented in Table SS-26, and the graphical presentations are shown in Figure 21 and Map 21 in the Reference Appendix.

TABLE SS-26
STATISTICAL SUMMARY FOR SILVER

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
562	0.32	101	1.3	26.9	5.2	1.8
Number of Values Per Class Interval						
0 - <1.0		1.0 - <4.0		4.0 - <20.0		≥20.0
473		59		25		5

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Silver was sporadically detected in samples collected from locations throughout the site. Most concentrations were in the lower range, although moderate concentrations were detected in a few samples collected from the BNR Dismantling Yard, the central section of the BNR Railyard, and from Amsted. High concentrations were detected in a few samples collected from scattered locations in the BNR Dismantling Yard and from Amsted. The maximum silver concentration, 101 mg/kg, was detected in the sample collected from location 855 in Amsted.

The mean silver concentration at STF cannot be compared to background concentrations because silver was not detected in samples collected offsite.

Sodium. Sodium was detected in 556 samples (94%). The statistical summary for all analyzed samples is presented in Table SS-27, and the graphical presentations are shown in Figure 22 and Map 22 in the Reference Appendix.

TABLE SS-27
STATISTICAL SUMMARY FOR SODIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	23.5	3,350	307	92,500	304	331
Number of Values Per Class Interval						
0 - <150	150 - <250	250 - <430	430 - <780	≥780		
153	181	161	67	28		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from the western portion of the Airport, from most of the Former Swamp/Lakebed, the southern section of the BNR Railyard, and from some portions of the BNR Dismantling Yard. Moderate concentrations were detected in samples collected from areas in the BNR Dismantling Yard, the northern section and some southern locations of the BNR Railyard, TIP, Amsted, and the eastern edge of the Airport. High concentrations were detected in samples collected from several locations throughout the BNR Dismantling Yard, primarily the northern end of the BNR Railyard, a few locations in the Airport, and one location each in Amsted and the Former Swamp/Lakebed. The maximum sodium concentration, 3,350 mg/kg, was detected in the sample collected from location 414 in the BNR Dismantling Yard.

The mean sodium concentration at STF is above the area background concentration of 125 mg/kg (95% UCL), but well within the common range for soil.

Thallium. Thallium was detected in 36 samples (7%). The statistical summary for all analyzed samples is presented in Table SS-28, and the graphical presentations are shown in Figure 23 and Map 23 in the Reference Appendix.

TABLE SS-28
STATISTICAL SUMMARY FOR THALLIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
547	0.06	6.7	0.75	1.7	1.3	0.86
Number of Values Per Class Interval						
0 - <0.25		0.25 - <2.0		≥ 2.0		
259		216		72		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were detected in samples collected from TIP, the Airport, the northern portion of the Former Swamp/Lakebed, and most of the BNR Railyard. Thallium was sporadically detected at moderate concentrations in the BNR Railyard, BNR Dismantling Yard, and the southern portion of the Former Swamp/Lakebed. The highest concentrations were detected in samples collected from the BNR Dismantling Yard. The maximum thallium concentration, 2.7 mg/kg, was detected in the sample collected from location 383 in the BNR Dismantling Yard. However, the spatial distribution of thallium in the BNR Dismantling Yard and Amsted cannot be fully evaluated because of the high detection limits associated with samples collected from those sampling units. Contract required detection limits were not achieved because of matrix interferences.

The mean thallium concentration at STF cannot be compared to background concentrations because thallium was not detected in samples collected offsite.

Vanadium. Vanadium was detected in 588 samples (approximately 100%). The statistical summary for all analyzed samples is presented in Table SS-29, and the graphical presentations are shown in Figure 24 and Map 24 in the Reference Appendix.

TABLE SS-29
STATISTICAL SUMMARY FOR VANADIUM

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	0.34	321	45.7	716	26.8	47.8
Number of Values Per Class Interval						
0 - <48.0	48.0 - <80.0	80.0 - <180	≥ 180			
399	165	23	3			

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, most samples collected from all the sampling units exhibited low concentrations of vanadium. Moderate concentrations were detected in a few samples collected from locations in the BNR Dismantling Yard, the northern and southern boundaries of the BNR Railyard, the eastern boundary of the Airport, and Amsted. High concentrations were detected in three samples collected from the southern boundary of the Former Swamp/Lakebed. The maximum vanadium concentration, 321 mg/kg, was detected in two different samples collected from locations 880 and 881 in the Former Swamp/Lakebed.

The mean vanadium concentration at STF was below the area background concentration of 32.0 mg/kg (95% UCL) and well within the common range for soil.

Zinc. Zinc was detected in 590 samples (100%). The statistical summary for all analyzed samples is presented in Table SS-30, and the graphical presentations are shown in Figure 25 and Map 25 in the Reference Appendix.

TABLE SS-30
STATISTICAL SUMMARY FOR ZINC

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	13.4	61,600	1,410	20.6x10 ⁶	4,540	1,780
Number of Values Per Class Interval						
0 - <195	195 - <380	380 - <1,100	1,100 - <5,000	≥5,000		
220	107	142	87	34		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Low concentrations were primarily detected in samples collected from the Former Swamp/Lakebed, TIP, and most of the Airport. Moderate concentrations were detected in samples collected from throughout the BNR Dismantling Yard, and from the BNR Railyard, Amsted, and the northeastern section of the Airport. The highest concentrations were detected in samples collected from the BNR Dismantling Yard, BNR Railyard, and the northern portion of Amsted. The maximum zinc concentration, 61,600 mg/kg, was detected in the sample collected from location 838 in Amsted.

The mean zinc concentration at STF was above the area background concentration of 94.8 mg/kg (95% UCL) and above the common range for soil.

4.1.3 Summary of Surface Soil Inorganic Analytical Results

This section presents a summary of the inorganic analytical results for each of the surface soil sampling units. In general, the distribution of inorganic substances throughout the STF site did not display apparent gradients. This lack of concentration gradients is consistent with the varied industrial operations that have occurred at the STF site and their associated multiple potential sources of contamination.

4.1.3.1 BNR Dismantling Yard. The BNR Dismantling Yard was the location for dismantling and salvaging of railroad equipment and parts. Locomotives were cut apart and taken offsite for disposal, while other waste materials were burned and/or buried onsite (see Section 1.4.1). The industrial nature of the site lasted for approximately 80 years. Disposal activities related to these industrial operations during that period plus emissions from the combustion of fuel oil and coal are likely the prime sources of elevated concentrations of inorganics detected at the site.

In general, elevated concentrations of inorganics were detected in samples collected from locations throughout the BNR Dismantling Yard. Only the northeast corner appears to consistently have the lowest detected concentrations in the sampling unit. Elevated concentrations of inorganics in soil were detected in the vicinity of the storage yard, rubbish track corridor, gantry crane, burn area, and trash pit (legend numbers 10, 11, 2, 8, and 9, respectively, in Figure SS-1). Disposal of waste coal, cinders, slag, and metal products in these locations probably contributed to the relatively elevated concentrations detected.

Several locations in the BNR Dismantling Yard along the sampling unit boundary shared with Tacoma City Light exhibit moderate to elevated concentrations of antimony, cadmium, chromium, copper, lead, manganese, mercury, and zinc. The source of these metals may be the historical operation of the gantry crane or migration of inorganic substances in stormwater from Tacoma City Light.

4.1.3.2 BNR Railyard. The BNR Railyard was the location of most of the industrial shops associated with repair and maintenance of locomotives, railcars, and other railroad equipment. The elevated concentrations of inorganics detected in the BNR Railyard are consistent with these former onsite activities, as well as the fallout of airborne particles from coal and fuel combustion. Generally, elevated concentrations of inorganics were detected in samples collected from the central and southern portion of the BNR Railyard, and from the northwest section adjacent to the BNR Dismantling Yard and the Airport (for some inorganics).

In the BNR Railyard, the most elevated concentrations of antimony, barium, cadmium, chromium, lead, manganese, mercury, and zinc were typically detected in the central and southern portions of the unit. Arsenic concentrations were elevated only in the central portion of the BNR Dismantling Yard. Concentrations of antimony, barium, lead, mercury, selenium, vanadium, and zinc were elevated in the northern portion of the BNR Railyard in samples collected adjacent to the BNR Dismantling Yard and the Airport.

Elevated concentrations of inorganics were detected in samples collected in the vicinity of the storage yard, trash burning area, paint shop, freight repair shed, open shed, wheel shop, south machine shop, trash burner, and turntable (legend numbers 10, 17, 18, 30, 24, 32, 47, 48, and 51, respectively, in Figure SS-1).

4.1.3.3 Amsted. Amsted was the former site of the Griffin Wheel Foundry Company which produced journal bearings for railcar axles. Material used in the manufacturing of the bearings included antimony, lead, tin, copper, and zinc. Air emissions, waste products, baghouse dust, and slag or slag-like materials were deposited in the immediate vicinity of the brass foundry. Samples collected from Amsted exhibited the most elevated concentrations of any sampling unit at the STF site for some inorganics, including copper, lead, manganese, nickel, silver, and zinc.

In addition, concentrations of cadmium, chromium, and mercury were also elevated at Amsted. The most elevated concentrations were typically detected in samples collected from the central portion of the sampling unit.

4.1.3.4 TIP. TIP includes portions of the old Griffin Wheel Iron Foundry and a small section of the Car Shops. The southern portion of TIP area is covered with buildings and pavement and was inaccessible for surface soil sampling. Analytical results for samples collected from the remaining locations that were accessible generally exhibited low concentrations of inorganics, except for antimony, calcium, manganese, and selenium, which were detected at elevated concentrations.

4.1.3.5 Airport. Low concentrations of inorganics were generally detected in samples collected from this unit. However, elevated concentrations of some chemicals of concern (in particular, antimony, chromium, and mercury) were detected in samples collected from the northern or northeastern portions of the unit, (i.e., areas adjacent to the BNR Dismantling Yard and BNR Railyard).

The storage yard that was present mainly in the BNR Dismantling Yard extended into the northwestern section of the Airport area. In addition, the Airport area adjacent to the BNR Railyard sampling unit is located near former disposal areas and industrial shops. Nearby industrial operations and disposal activities could account for the elevated concentrations detected in samples collected from the northern portion of this unit.

4.1.3.6 Former Swamp/Lakebed. Portions of the Former Swamp/Lakebed were used for the disposal of some materials, including foundry wastes generated from offsite operations. The most elevated concentrations of inorganics were detected in samples collected from the fill areas (see Figure SS-1) and occasionally along the southern edge of the area. Elevated concentrations of aluminum, antimony, barium, cadmium, calcium, chromium, iron, magnesium, manganese, nickel, potassium, selenium, and sodium were detected in samples collected from the areas historically used for disposal. The southernmost boundary locations of the Former Swamp/Lakebed exhibited elevated concentrations of barium, calcium, chromium, manganese, and vanadium. The potential sources of these metals may be located offsite because of the proximity of these locations to the STF site boundary.

4.1.4 Summary of Tacoma City Light Subsurface Inorganic Analytical Results

Inorganic analytical results for the Tacoma City Light subsurface investigation are summarized in Table SS-31. Complete analytical results are available in Section 7.0 of the Data Appendix. Concentrations of inorganics for these subsurface samples appear unevenly distributed and do not display any discernable trends (i.e., concentrations were not constant over the depth of the borings, nor did concentrations increase or decrease uniformly with depth). Instead, concentrations of chemicals of concern would often decrease (or increase) and then increase (or decrease) significantly over a relatively small distance.

Minimum detected concentrations of inorganics in Tacoma City Light subsurface samples were generally equivalent (approximately within 1 order of magnitude) to the minimum detected concentrations in surface soil throughout the STF site, except for iron. The subsurface minimum concentration of iron was 2 orders of magnitude greater than the onsite surface minimum concentration of iron. The subsurface maximum inorganic concentrations were significantly less (frequently by 1-2 orders of magnitude) than the maximum inorganic concentrations detected in onsite surface soil. Chromium (total) was the only inorganic that exhibited a higher subsurface maximum concentration than the maximum concentration detected in onsite surface soil.

All subsurface concentrations of barium were below the area surface soil background concentration (95% UCL), and the maximum concentrations of nickel and vanadium were only slightly above background concentrations (95% UCL) (see Table SS-5). Except for antimony, minimum detected concentrations were below the average area surface soil background concentrations (95% UCL). Maximum detected concentrations of inorganics in subsurface soil were typically 1 order of magnitude or less above the area surface soil background concentrations (95% UCL), except for chromium, copper, and sodium. The maximum subsurface concentration of chromium (total) was 2 orders of magnitude, and copper and sodium were between 1 and 2 orders of magnitude above area background surface soil concentrations (95% UCL).

TABLE SS-31

**SUMMARY OF INORGANIC ANALYTICAL RESULTS FOR
TACOMA CITY LIGHT DRY WELL SUBSURFACE SOIL SAMPLES AND
COMPARISON TO INORGANIC ANALYTICAL RESULTS FOR SURFACE SOIL SAMPLES**

Analyte	Number of Detected Values (32 maximum)	Number of Dry Wells (8 maximum)	TACOMA CITY LIGHT SUBSURFACE SOIL		STF SURFACE SOIL	
			Minimum Detected Concentration (mg/kg) [location/depth (ft)]	Maximum Detected Concentration (mg/kg) [location/depth (ft)]	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Aluminum	32	8	8,150 [DW 13/7]	20,800 [DW 18/11]	1,350	104,000
Antimony	4	2	9.8 [DW 26/9]	15.5 [DW 13/7]	4.6	491
Arsenic	27	8	1.1 [DW 13/13]	74.8 [DW 13/11]	0.73	696
Barium	32	8	25.2 [DW 13/13]	94.3 [DW 22/7]	9.9	2,600
Beryllium	0	0	— ^(a)	—	0.13	14.4
Boron	0	0	—	—	3.9	1,300
Cadmium	1	1	2.4 [DW 22/7]	2.4 [DW 22/7]	0.21	29.9
Calcium	32	8	1,820 [DW 10/9]	7,620 [DW 26/9]	245	323,000
Chromium (total)	32	8	12.4 [DW 15/11]	2,300 [DW 13/7]	2.9	707
Cobalt	32	8	4.6 [DW 10/9]	8.0 [DW 22/9]	2.0	135
Copper	32	8	7.3 [DW 22/11]	856 [DW 13/11]	7.2	163,000
Cyanide	0	0	—	—	0.50	2.3
Iron	32	8	13,300 [DW 13/7]	31,800 [DW 24/9]	135	298,000
Lead	32	8	7.5 [DW 18/15]	538 [DW 24/9]	5.3	118,000

TABLE SS-31

**SUMMARY OF INORGANIC ANALYTICAL RESULTS FOR
TACOMA CITY LIGHT DRY WELL SUBSURFACE SOIL SAMPLES AND
COMPARISON TO INORGANIC ANALYTICAL RESULTS FOR SURFACE SOIL SAMPLES**

Analyte	Number of Detected Values (32 maximum)	Number of Dry Wells (8 maximum)	TACOMA CITY LIGHT SUBSURFACE SOIL		STF SURFACE SOIL	
			Minimum Detected Concentration (mg/kg) [location/depth (ft)]	Maximum Detected Concentration (mg/kg) [location/depth (ft)]	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Magnesium	32	8	2,480 [DW 10/9]	6,870 [DW 18/11]	251	25,700
Manganese	32	8	174 [DW 13/13]	836 [DW 22/9]	22.7	21,800
Mercury	32	8	0.0018 [DW 10/11]	0.40 [DW 26/9]	0.0038	5.3
Nickel	32	8	16.80 [DW 10/9]	39.6 [DW 26/9]	2.8	865
Potassium	12	3	361 [DW 18/13]	772 [DW 18/11]	111	6,190
Selenium	1	1	0.48 [DW 22/7]	0.48 [DW 22/7]	0.12	141
Silver	0	0	—	—	0.90	101
Sodium	32	8	97 [DW 15/11]	3,250 [DW 22/7]	48.7	3,350
Thallium	1	1	1.2 [DW 26/11]	1.2 [DW 26/11]	0.11	2.7
Vanadium	32	8	14.2 [DW 10/9]	37.8 [DW 18/11]	1.5	321
Zinc	32	8	22.7 [DW 10/15]	480 [DW 26/9]	13.4	61,600

(a) — - Indicates no detected concentrations.

4.1.5 Summary of Pioneer Builders Supply Subsurface Inorganic Analytical Results

Inorganic analytical results for subsurface samples collected from Pioneer Builders Supply are summarized in Table SS-32. Complete analytical results are presented in Section 7.0 of the Data Appendix. Antimony, cadmium, selenium, silver, thallium, boron, and cyanide were not detected in any samples collected from the borings. Lead and copper were detected only in the samples from NMW1-A. Arsenic was detected in samples collected from NMW1-A and in one sample collected from B-2.

Generally, the inorganics detected in samples collected from Pioneer Builders Supply did not vary significantly with depth or among borings. Concentrations of inorganics in subsurface soil at Pioneer Builders Supply are below or only slightly above area background surface soil concentrations (95% UCL) (see Table SS-5). Of the inorganics detected in these subsurface soil samples, concentrations of aluminum, arsenic, barium, copper, lead, manganese, mercury, nickel, and zinc are all below area background surface soil concentrations (95% UCL). Beryllium, calcium, chromium (total), cobalt, iron, magnesium, potassium, sodium, and vanadium are only slightly elevated above area background surface soil concentrations (95% UCL) (see Table SS-5).

TABLE SS-32

**SUMMARY OF INORGANIC ANALYTICAL RESULTS (mg/kg)
FOR PIONEER BUILDERS SUPPLY SUBSURFACE SOIL SAMPLES**

	Boring B-1 ^(a,b)	Boring B-2 ^(a,b)		Boring B-3 ^(a,b)		Boring B-4 ^(a,b)	Boring NMW-1A ^(a,b)	
	23 ft	17 ft	32 ft	22 ft	27 ft	23 ft	33.5 ft	38.5 ft
Aluminum	8,040	13,300	10,300	11,100	9,140	8,040	12,300	9,090
Arsenic	— ^(c)	B 2.8	—	—	—	—	* S 4.5 J4	* S 2.7
Barium	BEN 39.8 J4	BEN 53.0 J4	BE 59.6 J4	BE 43.9 J4	BE 39.5 J4	BE 32.3 J4	E 52.1 J4	E 59.3 J4
Beryllium	B 0.36	B 0.52	B 0.35	B.041	B 0.35	B 0.38	—	—
Calcium	B 3,160	B 4,260	B 4,250	B 5,340	B 4,160	B 3,280	E * 4,340 J4	E * 4,280 J4
Chromium (Total)	17.2	34.7	24.5	31.8	29.1	20.4	EN * 40.5 J4	EN * 21.3 J4
Cobalt	B 5.5	7.3	B 5.5	6.2	B 5.5	5.6	—	—
Copper	—	—	—	—	—	—	8.5	5.8
Iron	11,700	18,100	15,300	15,000	16,400	8,690	* 18,600 J4	* 12,400 J4
Lead	—	—	—	—	—	—	2.9	2.1
Magnesium	B 3,500	B 5,240	B 5,630	5,630	B 5,690	B 4,330	E 5,000 J4	E 4,230 J4
Manganese	E 185 J4	E 259 J4	E * 257 J4	E * 275 J4	E * 279 J4	E * 196 J4	E 240.0 J4	E 212 J4
Mercury	0.011	0.011	B 0.01	B 0.0082	0.010	0.012	0.02	0.03
Nickel	22.2	30.5	23.1	28.4	25.8	27.0	28.3	23.2
Potassium	B 501	587	B 423	560.0	B 389	B 390.0	642	712
Sodium	B 155	B 164	B 173	B 215	B 128	B 161	B 248	B 256
Vanadium	B 21.5	B 37.7	B 29.6	29.2	27.1	24.1	E * 33.5 J4	E * 27.1 J4
Zinc	26.6	36.0	36.6	34.0	35.0	24.9	E 29.2 J4	E 22.9 J4

- (a) Each boring location column has three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is the reported concentration; and 3) the right margin contains the data valuation qualifiers.
- (b) Inorganic Data Qualifiers (also see Data Appendix):
- B - Reported value is less than the EPA Contract Required Detection Limit (CRDL), but greater than, or equal to, the Instrument Detection Limit (IDL).
 - N - Spike sample recovery not within control limits.
 - S - Reported value was determined by Method of Standard Additions.
 - E - Reported value is estimated because of interference.
 - * - Duplicate analysis is not within control limits.
 - J4 - Estimated value. Other QC outside control limits; bias not readily determined.
- (c) — - Undetected value (see Data Appendix for detection limits and associated qualifiers).

4.2 ORGANIC COMPOUNDS

This section presents analytical data for organic compounds, including polynuclear aromatic hydrocarbon compounds (PAHs), semivolatile organic compounds, volatile organic compounds (VOCs), pesticides, PCBs, and dioxins and furans for samples collected from background locations (Section 4.2.1) and from onsite locations (Section 4.2.2).

Analyses for PAHs were conducted using two methods: EPA Method 8310 which is specific for PAH compounds, and EPA Method 8270 for semivolatile organic compounds. All soil samples collected during this investigation were analyzed using Method 8310. Method 8270 was used to analyze all TCL semivolatile compounds, which only included analysis of approximately 20 percent of the onsite soil samples. Typically, the detected limits achieved for PAH compounds using Method 8310 are lower than detection limits obtained using Method 8270.

Only Method 8310 PAH data will be discussed in this report because detection levels attained are consistently lower than those for Method 8270 and data are available for all sample locations. Analytical data for both methods are provided in Section 7.0 of the Data Appendix.

4.2.1 Background Surface Soil Concentrations

4.2.1.1 PAHs. A summary of the analytical results for PAH compounds detected in background samples is presented in Table SS-33. Statistical summary are also included. Complete analytical results are available in Section 7.0 of the Data Appendix.

Sources of PAHs to the environment are both natural (e.g., forest fires and synthesis by plants and microorganisms) and anthropogenic. Anthropogenic sources are considered to be greater contributors of PAHs to the environment than natural sources (Edwards 1983). Anthropogenic sources usually involve the combustion of

TABLE SS-33

**SUMMARY OF PAH ANALYTICAL RESULTS (mg/kg)
FOR BACKGROUND SURFACE SOIL SAMPLES**

Chemical	Sample Location Concentrations											Minimum ^(a) Concentration	Maximum Concentration	Mean Concentration	Variance (mg/kg) ²	Standard Deviation	Upper 95% Confidence Interval
	961	962	963	964	965	966	967	968	969	970	971						
Phenanthrene	— ^(b)	0.033	0.076	0.091	0.051	0.016	—	0.026	0.066	0.016	—	0.006	0.091	0.04	0.001	0.03	0.06
Anthracene	—	—	—	J 0.009 ^(c)	J 0.006 ^(c)	J 0.003 ^(c)	—	—	0.014	—	—	0.003	0.014	0.007	0.000	0.003	0.01
Fluoranthene	—	0.034	—	—	0.095	—	—	0.066	0.200	—	—	0.010	0.20	0.04	0.003	0.06	0.08
Pyrene	—	0.081	0.16	0.071	0.13	0.05	0.017	0.082	0.22	0.026	—	0.006	0.22	0.08	0.004	0.07	0.12
Benzo(a)anthracene ^(d)	—	0.037	0.057	0.042	0.037	0.019	—	0.022	0.11	—	—	0.006	0.11	0.03	0.001	0.03	0.05
Chrysene ^(d)	—	0.049	0.076	0.070	0.066	0.026	—	0.034	0.13	0.013	—	0.006	0.13	0.04	0.001	0.04	0.07
Benzo(b)fluoranthene ^(d)	—	0.047	0.057	0.093	0.061	0.021	—	0.029	0.078	J 0.010 ^(c)	—	0.006	0.093	0.04	0.001	0.03	0.06
Benzo(k)fluoranthene ^(d)	—	—	0.021	0.025	0.019	—	—	0.013	0.049	—	—	0.005	0.049	0.02	0.0002	0.01	0.02
Benzo(a)pyrene ^(d)	—	—	0.050	0.053	0.044	0.030	—	0.029	0.092	J 0.01 ^(c)	—	0.006	0.092	0.03	0.001	0.03	0.05
Indeno(1,2,3-cd)pyrene ^(d)	—	0.030	0.043	0.073	0.047	0.023	—	0.027	—	—	—	0.006	0.073	0.02	0.0005	0.02	0.04
Benzo(g,h,i)perylene	—	0.027	0.057	0.036	0.036	—	—	—	0.029	—	—	0.010	0.057	0.02	0.0002	0.02	0.03

(a) Minimum concentration could be equal to one-half of the lowest undetected concentration (see Data Appendix for complete analytical results).

(b) — - Undetected value (also see Data Appendix for detection limits and associated qualifiers).

(c) J - Laboratory qualifier signifying estimated value.

(d) Probable human carcinogen (EPA 1991).

organic materials (e.g., coal), but also include vehicle emissions, abrasion of tire and asphalt surfaces, and wood stove emissions. Coal was used to heat homes before the gradual conversion to oil and natural gas in the 1950s.

Naphthalene, acenaphthylene, acenaphthene, fluorene, and dibenzo(a,h)anthracene were not detected in background surface soil samples. PAHs that are probable human carcinogens [benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene (EPA 1991)] were detected in many background samples. The maximum detected background concentration for a probable human carcinogenic PAH is 0.13 mg/kg (chrysene at location 969). The maximum detected concentration for noncarcinogenic PAH is 0.22 mg/kg (pyrene at location 969).

Location 969 (sample collected from the South End Recreation Area) exhibited the highest reported concentrations for most of the detected PAH compounds. Location 964 (sample collected northeast of the site) exhibited the highest reported concentrations for three PAH compounds [phenanthrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene]. PAH compounds were not detected at locations 961 and 971 (samples collected northeast of the site). Only one PAH (pyrene) was detected in location 967 collected from the most southerly background sample location relative to the STF site.

Except for location 969, samples collected from locations south of the STF site generally exhibited lower reported concentrations of PAHs than those samples collected north of the site. Background sample locations south of the site are in a relatively non-industrial area compared to background sample locations north of the STF site. The higher incidence of fossil fuel combustion from vehicles and from industrial sources north of the site may explain the detection of higher PAH concentrations in samples collected north of the site than those collected from locations south of the STF site.

4.2.1.2 Semivolatile Organic Compounds. Three semivolatile organic compounds were detected in background samples. N-nitroso-di-n-dipropylamine was detected at an estimated concentration of 370 $\mu\text{g/kg}$ at location 964. Di-n-butyl-phthalate was detected at an estimated concentration of 110 $\mu\text{g/kg}$ at location 962. Bis-(2-ethylhexyl)phthalate was detected in five samples. Concentrations of bis-(2-ethylhexyl)phthalate, all estimated, ranged from 94 $\mu\text{g/kg}$ to 280 $\mu\text{g/kg}$.

All samples collected from background locations exhibited tentatively identified compounds (TICs). The sample collected from location 968 exhibited the highest concentration of any single TIC, 5,400 $\mu\text{g/kg}$, for an unknown compound. Complete analytical results for semivolatile organic compounds, including TICs, are presented in Section 7.0 of the Data Appendix.

4.2.1.3 VOCs. Two compounds, methylene chloride and benzene, were detected in samples collected from background locations. Every background sample exhibited concentrations of methylene chloride. Concentrations ranged from 160 $\mu\text{g/kg}$ to 700 $\mu\text{g/kg}$. Methylene chloride is a common laboratory contaminant and it was detected in all associated laboratory blanks. Benzene was detected at an estimated concentration of 2 $\mu\text{g/kg}$ in one sample collected from location 961. Complete analytical results are available in Section 7.0 of the Data Appendix.

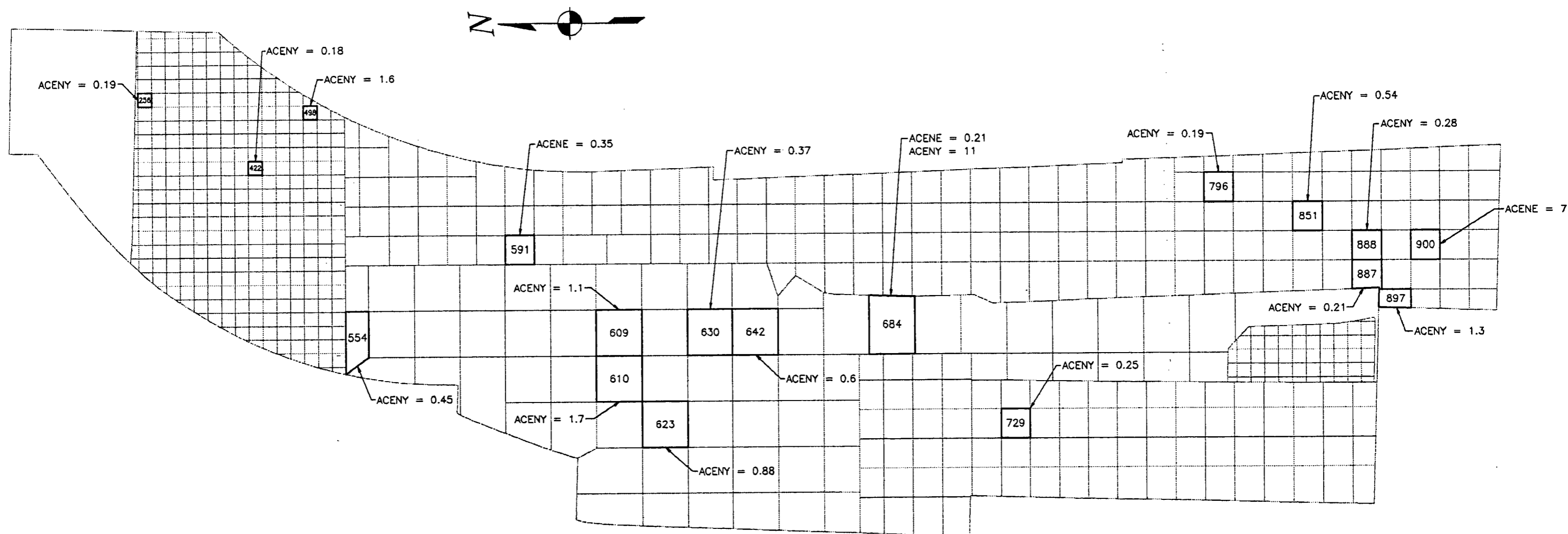
4.2.1.4 Pesticides/PCBs. One pesticide compound and one PCB compound were detected in two background samples. 4,4-DDT was detected at 120 $\mu\text{g/kg}$ in the sample collected from location 961 and Aroclor-1254 was detected at 190 $\mu\text{g/kg}$ in the sample collected from location 965. All other compounds were reported as undetected concentrations. Complete analytical results are available in Section 7.0 of the Data Appendix.

4.2.2 Onsite Surface Soil Concentrations

4.2.2.1 PAHs. Five-hundred ninety (590) samples (excluding duplicates) were analyzed for PAH compounds. Graphical presentations and concentration maps of PAH analytical results are available in the Reference Appendix. Complete analytical results, including laboratory and validation qualifiers, are presented in Section 7.0 of the Data Appendix. Most PAH compounds, except acenaphthylene and acenaphthene, were detected in more than 5 percent of the collected samples. Statistical summary and further discussion of acenaphthylene and acenaphthene are not presented in this section. The location and concentrations of samples exhibiting acenaphthylene and acenaphthene are shown in Figure SS-9.

For each PAH compound detected in more than 5 percent of the collected samples, a summary of the statistical results for all analyzed samples and the number of values within each class interval are presented in the following subsections. A brief description of the distribution of each PAH compound is also included. The terms low, moderate, and high, when referring to site concentrations, are used relative to concentrations reported in other samples collected from the STF site.

When five class intervals are shown on a distribution figure, low refers to the first and second class intervals; moderate refers to the third class interval; and high refers to the fourth and fifth class intervals. When six class intervals are presented, two intervals are grouped into each designation (i.e., two intervals each in the low, moderate, and high designation categories). When four intervals (including distribution figures for organic compounds) are presented, the first two intervals are described as low, the third is categorized as moderate, and the last class interval is deemed high. When three intervals are presented, the first class interval is called low, the second moderate, and the third high.



LEGEND

ACENY = 0.45
 0.45 mg/kg ACENAPHTHYLENE
 DETECTED AT LOCATION 554

ACENE - ACENAPHTHENE
 ACENY - ACENAPHTHYLENE

0 500 1000
 SCALE IN FEET

NOTE:
 ALL CONCENTRATIONS ARE IN mg/kg.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
 TACOMA, WA

**CONCENTRATIONS OF
 POLYNUCLEAR AROMATIC HYDROCARBONS
 SURFACE SOIL INVESTIGATION**

916055.02/P1SK311

FIGURE SS-9

Naphthalene. Naphthalene was detected in 113 samples (19%). The statistical summary for all analyzed samples is presented in Table SS-34, and the graphical presentations are shown in Figure 26 and Map 26 in the Reference Appendix.

TABLE SS-34
STATISTICAL SUMMARY FOR NAPHTHALENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.05	4.8	0.14	0.08	0.28	0.16
Number of Values Per Class Interval						
0 - <0.24		0.24 - <0.41		0.41 - <1.0		≥1.0
514		36		33		6

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Naphthalene was not detected or detected at low concentrations in samples collected from locations throughout the Former Swamp/Lakebed, TIP, Amsted, and the Airport (except one location). Naphthalene was detected primarily in samples collected from the BNR Railyard and BNR Dismantling Yard. Moderate and high concentrations were detected in samples collected from the north-central and southern portions of the BNR Railyard and from locations primarily in the southeastern portion of the BNR Dismantling Yard. The maximum naphthalene concentration, 4.8 mg/kg, was detected in the sample collected from location 900 in the BNR Railyard.

Fluorene. Fluorene was detected in 65 samples (11%). The statistical summary for all analyzed samples is presented in Table SS-35, and the graphical presentations are shown in Figure 27 and Map 27 in the Reference Appendix.

TABLE SS-35
STATISTICAL SUMMARY FOR FLUORENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	0.99	0.03	0.01	0.08	0.04
Number of Values Per Class Interval						
0 - <0.041		0.041 - <0.15	0.15 - <0.75	≥0.75		
540		35	10	4		

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Fluorene was not detected or detected at low concentrations in samples collected from most locations throughout the site. The distribution of detected concentrations of fluorene is confined primarily to localized areas in the BNR Dismantling Yard, BNR Railyard, and Amsted. Moderate concentrations were detected primarily at a few scattered areas in the BNR Dismantling Yard, the BNR Railyard, Amsted, and scattered locations in other sampling units. High concentrations were detected mainly in a few samples collected from the BNR Dismantling Yard, the BNR Railyard, and Amsted. The maximum fluorene concentration, 0.99 mg/kg, was detected in the sample collected from location 457 in the BNR Dismantling Yard.

Phenanthrene. Phenanthrene was detected in 525 samples (89%). The statistical summary for all analyzed samples is presented in Table SS-36, and the graphical presentations are shown in Figure 28 and Map 28 in the Reference Appendix.

TABLE SS-36
STATISTICAL SUMMARY FOR PHENANTHRENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	15	0.37	0.86	0.93	0.45
Number of Values Per Class Interval						
0 - <0.17	0.17 - <0.48		0.48 - <1.4		≥ 1.4	
325	156		78		30	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, phenanthrene was detected in samples collected from locations throughout the STF site. Low concentrations were detected primarily in samples collected from the Former Swamp/Lakebed, the western portion of the Airport, and the west and central areas in the BNR Dismantling Yard. Moderate to high concentrations were detected in samples collected from the northern and eastern edges of the BNR Dismantling Yard, primarily from some locations along the eastern edge and in the southern section of the BNR Railyard, the northern section of Amsted, and a few locations in the remaining sampling units. The maximum phenanthrene concentration, 15 mg/kg, was detected in the sample collected from location 457 in the BNR Dismantling Yard.

The mean phenanthrene concentration at STF was above the area background concentration, 0.06 mg/kg (95% UCL).

Anthracene. Anthracene was detected in 306 samples (52%). The statistical summary for all analyzed samples is presented in Table SS-37, and the graphical presentations are shown in Figure 29 and Map 29 in the Reference Appendix.

TABLE SS-37
STATISTICAL SUMMARY FOR ANTHRACENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.02	2.7	0.05	0.03	0.18	0.07
Number of Values Per Class Interval						
0 - <0.031		0.031 - <0.090		0.090 - <0.38		≥0.38
428		99		46		16

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Anthracene was not detected or detected at low concentrations in samples collected primarily from TIP, the Airport, the Former Swamp/Lakebed, and the west-central portion of the BNR Dismantling Yard. Moderate to high concentrations were detected primarily in samples collected from several locations throughout the BNR Dismantling Yard (except the west-central portion), throughout the BNR Rail yard and Amsted, and a few locations in the Airport and the Former Swamp/Lakebed. The maximum anthracene concentration, 2.7 mg/kg, was detected in the sample collected from location 457 in the BNR Dismantling Yard.

The mean anthracene concentration at STF was above the area background concentration, 0.01 mg/kg (95% UCL).

Fluoranthene. Fluoranthene was detected in 387 samples (66%). The statistical summary for all analyzed samples is presented in Table SS-38, and the graphical presentations are shown in Figure 30 and Map 30 in the Reference Appendix.

TABLE SS-38
STATISTICAL SUMMARY FOR FLUORANTHENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	23	0.72	3.4	1.9	0.87
Number of Values Per Class Interval						
0 - <0.43		0.43 - <1.31		1.31 - <4.4		≥4.4
395		118		56		20

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Fluoranthene was not detected or detected at low concentrations in the Airport, the Former Swamp/Lakebed and the west-central portion of the BNR Dismantling Yard. Moderate to high concentrations were detected in samples collected from the northern and eastern edges of the BNR Dismantling Yard, the eastern portion of the central section and the southern section in the BNR Railyard, throughout but particularly the northern portion of Amsted, three adjacent sampling locations in TIP, and a few scattered locations in the remaining sampling units. The maximum fluoranthene concentration, 23 mg/kg, was detected in the sample collected from location 457 in the BNR Dismantling Yard.

The mean fluoranthene concentration at STF was above the area background concentration, 0.08 mg/kg (95% UCL).

Pyrene. Pyrene was detected in 464 samples (79%). The statistical summary for all analyzed samples is presented in Table SS-39, and the graphical presentations are shown in Figure 31 and Map 31 in the Reference Appendix.

TABLE SS-39
STATISTICAL SUMMARY FOR PYRENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	23	0.59	3.0	1.8	0.73
Number of Values Per Class Interval						
0 - <0.25		0.25 - <0.80		0.80 - <3.0		≥3.0
356		140		70		23

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Pyrene was not detected or detected at low concentrations in most samples collected from the western portion of the Airport, the west and central portions of the BNR Dismantling Yard, the eastern section of TIP, and most of the Former Swamp/Lakebed. Moderate to high concentrations were detected in samples collected from the northern and eastern areas of the BNR Dismantling Yard, throughout the BNR Railyard and Amsted, the eastern edge of the Airport, and a few locations in the remaining sampling units. The maximum pyrene concentration, 23 mg/kg, was detected in the sample collected from location 298 in the BNR Dismantling Yard.

The mean concentration of pyrene at STF was above the area background concentration, 0.12 mg/kg (95% UCL).

Benzo(a)anthracene. Benzo(a)anthracene was detected in 429 samples (73%). The statistical summary for all analyzed samples is presented in Table SS-40, and the graphical presentations are shown in Figure 32 and Map 32 in the Reference Appendix.

TABLE SS-40
STATISTICAL SUMMARY FOR BENZO(a)ANTHRACENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	9.4	0.24	0.47	0.69	0.30
Number of Values Per Class Interval						
0 - <0.11	0.11 - <0.32		0.32 - <1.55		≥ 1.55	
377	128		64		20	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Benzo(a)anthracene was not detected or detected at low concentrations in samples collected from the western two-thirds of the Airport, the eastern portion of TIP, large sections of the BNR Dismantling Yard, and from several portions of the Former Swamp/Lakebed. Moderate to high concentrations were detected in samples collected from the locations in the outlying sections of the BNR Dismantling Yard, throughout the length of the BNR Railyard, throughout Amsted, locations (particularly in the central section) in the Former Swamp/Lakebed, and two locations in TIP. The maximum benzo(a)anthracene concentration, 9.4 mg/kg, was detected in the sample collected from location 457 in the BNR Dismantling Yard.

The mean benzo(a)anthracene concentration at the STF site was above the area background concentration, 0.05 mg/kg (95% UCL).

Chrysene. Chrysene was detected in 517 samples (88%). The statistical summary for all analyzed samples is presented in Table SS-41, and the graphical presentations are shown in Figure 33 and Map 33 in the Reference Appendix.

TABLE SS-41
STATISTICAL SUMMARY FOR CHRYSENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	9.9	0.32	0.64	0.80	0.39
Number of Values Per Class Interval						
0 - <0.15	0.15 - <0.36		0.36 - <1.68		≥ 1.68	
341	145		79		24	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Chrysene was not detected or detected in low concentrations in samples collected from the western two-thirds of the Airport, the eastern portion of TIP, the central and western portions of the BNR Dismantling Yard, and most locations of the Former Swamp/Lakebed. Moderate to high concentrations were detected in samples collected from the outer edges of the BNR Dismantling Yard, the northern half and the southern end of the BNR Railyard, the northern section of Amsted, the northern end and eastern edge of the Airport, a few locations in the Former Swamp/Lakebed, and the western portion of TIP. The maximum chrysene concentration, 9.9 mg/kg, was detected in the sample collected from location 457 in the BNR Dismantling Yard.

The mean chrysene concentration at the STF site was above the area background concentration, 0.07 mg/kg (95% UCL).

Benzo(b)fluoranthene. Benzo(b)fluoranthene was detected in 519 samples (88%). The statistical summary for all analyzed samples is presented in Table SS-42, and the graphical presentations are shown in Figure 34 and Map 34 in the Reference Appendix.

TABLE SS-42
STATISTICAL SUMMARY FOR BENZO(b)FLUORANTHENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	6.8	0.34	0.54	0.73	0.40
Number of Values Per Class Interval						
0 - <0.16	0.16 - <0.43		0.43 - <1.65		≥ 1.65	
332	156		77		24	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, benzo(b)fluoranthene was detected in samples collected from locations throughout the STF site, and its spatial distribution is very similar to chrysene. Benzo(b)fluoranthene was not detected or detected at low concentrations in samples collected from the west and central portions of the BNR Dismantling Yard, the western two-thirds in the Airport, and from most locations of the Former Swamp/Lakebed. Moderate to high concentrations were detected in samples collected from the outer edges of the BNR Dismantling Yard, throughout the BNR Railyard and especially in the southern end, the northern section of Amsted, along the eastern and northern boundary of the Airport, along the western boundary of TIP, and several locations in the Former Swamp/Lakebed. The maximum benzo(b)fluoranthene concentration, 6.8 mg/kg, was detected in the sample collected from location 900 in the BNR Railyard.

The mean benzo(b)fluoranthene concentration at the STF site was above the area background concentration, 0.06 mg/kg (95% UCL).

Benzo(k)fluoranthene. Benzo(k)fluoranthene was detected in 421 samples (71%). The statistical summary for all analyzed samples is presented in Table SS-43, and the graphical presentations are shown in Figure 35 and Map 35 in the Reference Appendix.

TABLE SS-43
STATISTICAL SUMMARY FOR BENZO(k)FLUORANTHENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	3.9	0.16	0.15	0.39	0.2
Number of Values Per Class Interval						
0 - <0.081	0.081 - <0.25		0.25 - <0.95		≥0.95	
373	133		61		22	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, benzo(k)fluoranthene was detected in samples collected from locations throughout the site. Benzo(k)fluoranthene exhibits a spatial distribution similar to the previous two PAH compounds [chrysene and benzo(b)fluoranthene], but typically had lower concentrations than those compounds. Benzo(k)fluoranthene was not detected or detected at low concentrations in samples collected from the northeast corner and the central and western portions of the BNR Dismantling Yard, the western two-thirds of the Airport, most of the Former Swamp/Lakebed, the eastern section of TIP, and portions of Amsted. Moderate to high concentrations were detected in samples collected primarily from locations in the southeastern and northwestern sections of the BNR Dismantling Yard, throughout the BNR Railyard, the northern section of Amsted, a few locations in the western portion of TIP, and locations mainly near the eastern boundary of the Former Swamp/Lakebed. The maximum benzo(k)fluoranthene concentration, 3.9 mg/kg, was detected in the sample collected from location 789 in the Former Swamp/Lakebed.

The mean benzo(k)fluoranthene concentrations at STF was above the area background concentration, 0.02 mg/kg (95% UCL).

Benzo(a)pyrene. Benzo(a)pyrene was detected in 437 samples (74%). The statistical summary for all analyzed samples is presented in Table SS-44, and the graphical presentations are shown in Figure 36 and Map 36 in the Reference Appendix.

TABLE SS-44
STATISTICAL SUMMARY FOR BENZO(a)PYRENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	8.9	0.29	0.54	0.74	0.35
Number of Values Per Class Interval						
0 - <0.15	0.15 - <0.43		0.43 - <1.8		≥ 1.8	
365	137		65		22	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, benzo(a)pyrene was detected in samples collected from locations throughout the STF site at concentrations and spatial distribution similar to benzo(a)anthracene, chrysene, and benzo(b)fluoranthene. Benzo(a)pyrene was not detected or detected at low concentrations in samples collected from the central and western portions of the BNR Dismantling Yard, most of the Airport, most of the Former Swamp/Lakebed, the eastern portion of TIP, and some locations in the southern portion of Amsted. Moderate to high concentrations were detected in samples collected from locations primarily in the southeastern and northern sections of the BNR Dismantling Yard, many locations throughout the length of the BNR Railyard, primarily the northern section of Amsted, several locations grouped together in the central portion of the Former Swamp/Lakebed, and from the western edge in TIP. The maximum benzo(a)pyrene concentration, 8.9 mg/kg, was detected in the sample collected from location 789.

The mean benzo(a)pyrene concentration was above the area background concentration, 0.05 mg/kg (95% UCL).

Indeno(1,2,3-cd)pyrene. Indeno(1,2,3-cd)pyrene was detected in 469 samples (80%). The statistical summary for all analyzed samples is presented in Table SS-45, and the graphical presentations are shown in Figure 37 and Map 37 in the Reference Appendix.

TABLE SS-45

STATISTICAL SUMMARY FOR INDENO(1,2,3-cd)PYRENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	6.7	0.22	0.29	0.54	0.27
Number of Values Per Class Interval						
0 - <0.11	0.11 - <0.31		0.31 - <1.1		≥1.1	
348	145		72		24	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

In general, indeno(1,2,3-cd)pyrene was detected in samples collected from locations throughout the STF site. The spatial distribution for indeno(1,2,3-cd)pyrene is similar to several other PAH compounds previously discussed [e.g., benzo(a)pyrene]. Indeno(1,2,3-cd)pyrene was not detected or detected at low concentrations in samples collected from the western and central portions of the BNR Dismantling Yard, the western two-thirds of the Airport, the southwestern portion of the Former Swamp/Lakebed, the eastern portion of TIP, and some locations in the southern section of Amsted. Moderate to high concentrations were detected in samples collected from locations primarily in the eastern half and northern and southern boundaries of the BNR Dismantling Yard, several locations throughout the length of the BNR Railyard, primarily the northern section of Amsted, from several locations in the southeastern portion of the Former Swamp/Lakebed, along the northern and eastern borders of the Airport, and two locations along the western edge of TIP. The maximum indeno(1,2,3-cd)pyrene concentration, 6.7 mg/kg, was detected in the sample collected from location 789 in the Former Swamp/Lakebed.

The mean indeno(1,2,3-cd)pyrene concentration at STF was above the average area background concentration, 0.04 mg/kg (95% UCL).

Dibenzo(a,h)anthracene. Dibenzo(a,h)anthracene was detected in 57 samples (10%). The statistical summary for all analyzed samples is presented in Table SS-46, and the graphical presentations are shown in Figure 38 and Map 38 in the Reference Appendix.

TABLE SS-46
STATISTICAL SUMMARY FOR DIBENZO(a,h)ANTHRACENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	1.0	0.03	0.00	0.07	0.03
Number of Values Per Class Interval						
0 - <0.051	0.051 - <0.16		0.16 - <0.48		≥0.48	
545	32		9		3	

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Most samples did not exhibit concentrations of dibenzo(a,h)anthracene above detection levels. Dibenzo(a,h)anthracene was detected most frequently in samples collected from the BNR Dismantling Yard and Amsted. Most of the highest concentrations were detected in samples collected from the BNR Dismantling Yard. The maximum dibenzo(a,h)anthracene concentration, 1.0 mg/kg, was detected in the sample collected from location 684 in the Airport.

Benzo(g,h,i)perylene. Benzo(g,h,i)perylene was detected in 377 samples (64%). The statistical summary for all analyzed samples is presented in Table SS-47, and the graphical presentations are shown in Figure 39 and Map 39 in the Reference Appendix.

TABLE SS-47
STATISTICAL SUMMARY FOR BENZO(g,h,i)PERYLENE

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
589	0.01	7.6	0.22	0.36	0.60	0.27
Number of Values Per Class Interval						
0 - <0.15		0.15 - <0.38		0.38 - <1.29		≥ 1.29
401		111		56		21

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Benzo(g,h,i)perylene was not detected or detected at low concentrations in samples collected from locations in the western portion of the Airport, the eastern section of TIP, the southern portion of the Former Swamp/Lakebed, and large portions of the BNR Dismantling Yard. Moderate to high concentrations were detected in samples collected primarily from the eastern, southern, and northwestern portions of the BNR Dismantling Yard, throughout but particularly in the southern section of the BNR Railyard, throughout Amsted, the central section of the Former Swamp/Lakebed, and from TIP. The maximum benzo(g,h,i)perylene concentration, 7.6 mg/kg, was detected in the sample collected from location 789 in the Former Swamp/Lakebed.

The mean benzo(g,h,i)perylene concentration at STF was above the area background concentration, 0.03 mg/kg (95% UCL).

Total Probable Carcinogenic PAHs. Total probable carcinogenic PAHs were calculated for each sampling location by summing the concentrations of all probable carcinogenic PAHs. If a probable carcinogenic PAH was not detected at the sampling location, a value equal to one-half the detection limit was used. Probable carcinogenic PAHs include benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and dibenzo(a,h)anthracene (EPA 1991).

One or more probable carcinogenic PAHs were detected in most samples. The statistical summary for all analyzed samples are presented in Table SS-48, and the graphical presentations are shown in Figure 40 and Map 40 in the Reference Appendix.

TABLE SS-48

STATISTICAL SUMMARY FOR TOTAL PROBABLE CARCINOGENIC PAHs

Number of Values	Minimum Concentration ^(a) (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Variance (mg/kg) ²	Standard Deviation (mg/kg)	95% UCL (mg/kg)
590	0.04	38.5	1.6	13.7	3.7	1.8
Number of Values Per Class Interval						
0 - <0.66	0.66 - <1.75	1.75 - <7.5	≥7.5			
317	158	87	27			

(a) The minimum concentration could be equal to one-half of the lowest undetected value.

Potential carcinogenic PAH compounds were detected in samples collected from locations throughout the site and displayed a spatial distribution similar to the individual PAH compounds previously discussed [except dibenzo(a,h)anthracene]. Low concentrations were detected in samples collected from a large contiguous area extending from the northeastern corner through the central area to the southwestern corner of the BNR Dismantling Yard, the western two-thirds of the Airport, and most of the Former Swamp/Lakebed. In addition, concentrations were also low in some samples collected from TIP and Amsted. Moderate to high

concentrations were detected in samples collected from the eastern and northern portions in the BNR Dismantling Yard, locations throughout the BNR Railyard, most locations in Amsted, along the northern and eastern boundary of the Airport, and locations in the Former Swamp/Lakebed, particularly along the eastern boundary with TIP and Amsted. The maximum total probable carcinogenic PAHs concentration, 38.5 mg/kg, was detected in the sample collected from location 487 in the BNR Dismantling Yard.

Total PAHs. Except for acenaphthylene, acenaphthene, fluorene, and dibenzo(a,h)anthracene, total PAH compounds displayed similar spatial distributions to individual PAH compounds. Concentrations of total PAHs were typically lowest in samples collected from the central and western portions of the BNR Dismantling Yard, the western portion of the Airport, and southwestern corner and the northern portion of the Former Swamp/Lakebed. Moderate to high concentrations were typically detected in samples collected from the northern boundary and the eastern portion of the BNR Dismantling Yard, the northern portion of Amsted and along the northern and eastern boundary of the Airport. Moderate to high concentrations of total PAHs were also detected in samples collected from locations throughout the BNR Railyard, in particular along the eastern boundary in the northern half and in the southern portion, and in the western portion of TIP.

4.2.2.2 Semivolatile Organic Compounds. One-hundred twenty-three (123) samples (excluding duplicates) were analyzed for semivolatile organic compounds. Semivolatile organic compounds were generally undetected or detected in only a few samples. [As mentioned in Section 4.2.1.2, PAHs detected in samples collected for semivolatile organic compound analysis (EPA Method 8270) will not be discussed in this section.] Graphical presentations and concentration maps of semivolatile organic compounds analytical results are available in the Reference Appendix. Complete analytical results, including laboratory and validation qualifiers, are presented in Section 7.0 of the Data Appendix.

Semivolatile organic compounds detected in less than 5 percent of the samples analyzed include phenol, 2-methylphenol, dimethylphthalate, 4-nitrophenol,

diethylphthalate, n-nitrosodiphenylamine, pentachlorophenol, 3,3-dichlorobenzidine, and di-n-octylphthalate. Table SS-49 presents the number of samples collected from the STF site with semivolatile organic compounds detected in less than 5 percent of the analyzed samples for each chemical of concern. Figure SS-10 presents the locations and concentrations of these detected semivolatile organic compounds.

TABLE SS-49

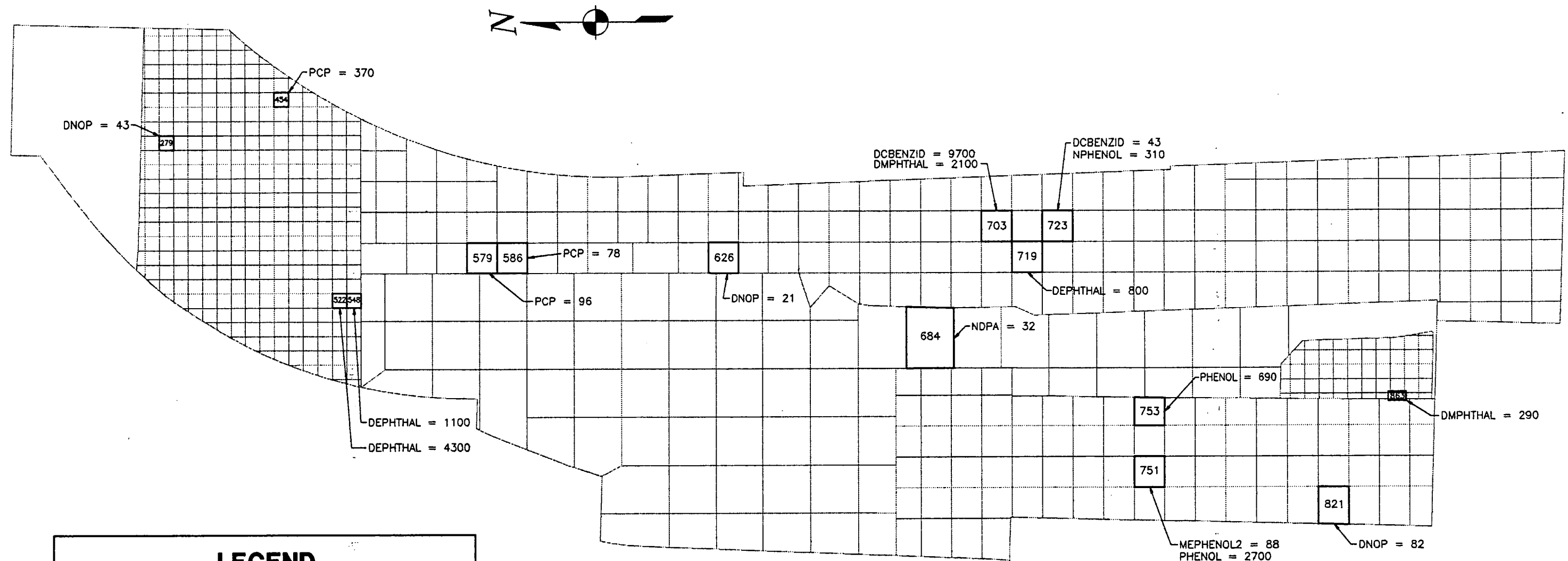
**SUMMARY OF SEMIVOLATILE ORGANIC COMPOUNDS
DETECTED IN LESS THAN 5 PERCENT OF SURFACE SOIL SAMPLES**

Chemical of Concern	Number of Detected Values	Maximum Concentration ($\mu\text{g/kg}$)
Phenol	2	2,700
2-Methylphenol	1	J ^(a) 88
Dimethylphthalate	2	2,100
4-Nitrophenol	1	J 310 J4 ^(b)
Diethylphthalate	3	4,300
N-nitrosodiphenylamine	1	J 32 J4
Pentachlorophenol	3	J 370
3,3'-Dichlorobenzidine	2	9,700
Di-n-octylphthalate	4	J 100

(a) J - Laboratory qualifier signifying estimated value.

(b) J4 - Validation qualifier signifying estimated value.

For each semivolatile organic compound detected in more than 5 percent of the collected samples, a summary of the statistical results and the number of values detected within each class interval are presented in the following subsections. A brief description of the distribution of each semivolatile organic compound is also included. The terms low, moderate, and high, when referring to site concentrations, are used relative to concentrations reported in other samples collected from the STF site.



LEGEND

DNOP = 21
 626 21 ug/kg DI-N-OCTYLPHTHALATE
 DETECTED AT LOCATION 626

DCBENZID	-	3,3-DICHLOROBENZIDINE
DEPTHAL	-	DIETHYLPHTHALATE
DMPHTHAL	-	DIMETHYLPHTHALATE
DNOP	-	DI-N-OCTYLPHTHALATE
MEPHENOL2	-	2-METHYLPHENOL
NDPA	-	N-NITROSODIPHENYLAMINE
NPHENOL	-	4-NITROPHENOL
PCP	-	PENTACHLOROPHENOL
PHENOL	-	PHENOL

0 500 1000
 SCALE IN FEET

NOTE:

ALL CONCENTRATIONS ARE IN ug/kg.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
 TACOMA, WA

**CONCENTRATIONS OF
 SEMIVOLATILE ORGANIC COMPOUNDS
 SURFACE SOIL INVESTIGATION**

916055.02/P1SK308

FIGURE SS-10

2-Methylnaphthalene. 2-Methylnaphthalene was detected in 55 samples (45%). The statistical summary for all analyzed samples is presented in Table SS-50, and the graphical presentations are shown in Figure 41 and Map 41 in the Reference Appendix.

TABLE SS-50
STATISTICAL SUMMARY FOR 2-METHYLNAPHTHALENE

Number of Values	Minimum Concentration ^(a) (µg/kg)	Maximum Concentration (µg/kg)	Mean Concentration (µg/kg)	Variance (µg/kg) ²	Standard Deviation (µg/kg)	95% UCL (µg/kg)
121	22	5,700	600	880,000	940	770
Number of Values Per Class Interval						
0 - <180	180 - <340	340 - <1,400	≥1,400			
36	41	31	13			

(a) Concentration could be equal to one-half of the detection limit.

2-Methylnaphthalene was most frequently detected in samples collected from the BNR Dismantling Yard and BNR Railyard, although all other sampling units (except Amsted) exhibited one or two detected values. Moderate and high concentrations were generally detected in samples collected from the BNR Railyard. The maximum 2-methylnaphthalene concentration, 5,700 µg/kg, was detected in the sample collected from location 703 in the BNR Railyard.

Dibenzofuran. Dibenzofuran was detected in 26 samples (21%). The statistical summary for all analyzed samples is presented in Table SS-51, and the graphical presentations are shown in Figure 42 and Map 42 of the Reference Appendix.

TABLE SS-51

STATISTICAL SUMMARY FOR DIBENZOFURAN

Number of Values	Minimum Concentration ^(a) ($\mu\text{g/kg}$)	Maximum Concentration ^(b) ($\mu\text{g/kg}$)	Mean Concentration ($\mu\text{g/kg}$)	Variance ($\mu\text{g/kg}$) ²	Standard Deviation ($\mu\text{g/kg}$)	95% UCL ($\mu\text{g/kg}$)
121	38	4,700	640	730,000	860	790
Number of Values Per Class Interval						
0 - <95	95 - <220		220 - <3,100		$\geq 3,100$	
13	50		53		5	

(a) Concentration could be equal to one-half of the detection limit.

(b) Maximum concentration is equal to one-half of the highest undetected value.

All dibenzofuran concentrations (except for one sample collected from the Airport adjacent to BNR Railyard) were detected in samples collected from scattered locations in the BNR Dismantling Yard and the BNR Railyard. Dibenzofuran was most frequently detected in samples collected from the BNR Dismantling Yard. The maximum dibenzofuran concentration, 3,200 $\mu\text{g/kg}$, was detected in the sample collected from location 703 in the BNR Railyard.

Carbazole. Carbazole was detected in 32 samples (26%). The statistical summary for all analyzed samples is presented in Table SS-52, and the graphical presentations are shown in Figure 43 and Map 43 of the Reference Appendix.

TABLE SS-52
STATISTICAL SUMMARY FOR CARBAZOLE

Number of Values	Minimum Concentration ^(a) ($\mu\text{g/kg}$)	Maximum Concentration ($\mu\text{g/kg}$)	Mean Concentration ($\mu\text{g/kg}$)	Variance ($\mu\text{g/kg}$) ²	Standard Deviation ($\mu\text{g/kg}$)	95% UCL ($\mu\text{g/kg}$)
121	42	5,600	650	840,000	910	820
Number of Values Per Class Interval						
0 - <225	225 - <700		700 - <1,400		$\geq 1,400$	
58	23		28		12	

(a) Concentration could be equal to one-half of the detection limit.

All carbazole concentrations (except for two samples collected from the Airport adjacent to the BNR Railyard) were detected in samples collected from locations in the BNR Dismantling Yard and BNR Railyard. Carbazole was most frequently detected in samples collected from the BNR Dismantling Yard. The maximum carbazole concentration, 5,600 $\mu\text{g/kg}$, was detected in the sample collected from location 703 in the BNR Railyard.

Di-n-butylphthalate. Di-n-butylphthalate was detected in 26 samples (21%). The statistical summary for all analyzed samples is presented in Table SS-54, and the graphical presentations are shown in Figure 44 and Map 44 of the Reference Appendix.

TABLE SS-53

STATISTICAL SUMMARY FOR DI-N-BUTYLBENZYLPHthalate

Number of Values	Minimum Concentration ^(a) ($\mu\text{g/kg}$)	Maximum Concentration ^(b) ($\mu\text{g/kg}$)	Mean Concentration ($\mu\text{g/kg}$)	Variance ($\mu\text{g/kg}$) ²	Standard Deviation ($\mu\text{g/kg}$)	95% UCL ($\mu\text{g/kg}$)
122	38	4,700	600	740,000	860	750
Number of Values Per Class Interval						
0 - <350	350 - <2,600		2,600 - <3,200		$\geq 3,200$	
74	40		4		34	

(a) Concentration could be equal to one-half of the detection limit.

(b) Maximum concentration is equal to one-half of the maximum undetected value.

Di-n-butylbenzylphthalate was detected in one or more samples collected from the BNR Dismantling Yard, BNR Railyard, Former Swamp/Lakebed, and the Airport. Most concentrations were detected in samples collected from the BNR Dismantling Yard, and most of the moderate to high concentrations were detected in this sampling unit. The maximum di-n-butylbenzylphthalate concentration, 3,200 $\mu\text{g/kg}$, was detected in two samples: one collected from location 400 in the BNR Dismantling Yard and one collected from location 703 in the BNR Railyard. Di-n-butylbenzylphthalate was also detected in the laboratory blank for both analyses.

Butylbenzylphthalate. Butylbenzylphthalate was detected in 15 samples (12%).

The statistical summary for all analyzed samples is presented in Table SS-54, and the graphical presentations are shown in Figure 45 and Map 45 of the Reference Appendix.

TABLE SS-54

STATISTICAL SUMMARY FOR BUTYLBENZYLPHTHALATE

Number of Values	Minimum Concentration ^(a) ($\mu\text{g/kg}$)	Maximum Concentration ^(b) ($\mu\text{g/kg}$)	Mean Concentration ($\mu\text{g/kg}$)	Variance ($\mu\text{g/kg}$) ²	Standard Deviation ($\mu\text{g/kg}$)	95% UCL ($\mu\text{g/kg}$)
121	49	4,700	640	680,000	820	780
Number of Values Per Class Interval						
0 - <100	100 - <280		280 - <600		≥ 600	
8	56		17		40	

(a) Concentration could be equal to one-half of the detection limit.

(b) Maximum concentration is equal to one-half of the maximum undetected value.

Nearly all butylbenzylphthalate concentrations were detected in samples collected from the BNR Dismantling Yard, although one concentration each was detected in the sample collected from the Former Swamp/Lakebed and BNR Railyard. The maximum butylbenzylphthalate concentration, 2,200 $\mu\text{g/kg}$ was detected in the sample collected from location 703 in the BNR Railyard.

Bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate was detected in 34 samples (28%). The statistical summary for all analyzed samples is presented in Table SS-55, and the graphical presentations are shown in Figure 46 and Map 46 of the Reference Appendix.

TABLE SS-55
STATISTICAL SUMMARY FOR BIS(2-ETHYLHEXYL)PHTHALATE

Number of Values	Minimum Concentration ^(a) (µg/kg)	Maximum Concentration ^(b) (µg/kg)	Mean Concentration (µg/kg)	Variance (µg/kg) ²	Standard Deviation (µg/kg)	95% UCL (µg/kg)
122	14	4,350	500	670,000	820	640
Number of Values Per Class Interval						
0 - <150	150 - <270	270 - <1,200	≥ 1,200			
45	36	25	16			

(a) Concentration could be equal to one-half of the detection limit.

(b) Maximum concentration is equal to one-half of the maximum undetected value.

Most bis(2-ethylhexyl)phthalate concentrations were detected in samples collected from the BNR Dismantling Yard and BNR Railyard, although all sampling units (except Amsted) exhibited some detectable concentrations. The locations and range of concentrations were scattered throughout the sampling units. The maximum bis(2-ethylhexyl)phthalate concentration, 4,200 µg/kg (estimated concentration and analyte detected in laboratory blank), was detected in the sample collected from location 703 in the BNR Railyard.

TICs. TICs were detected in samples collected from all sampling units, but primarily from the BNR Dismantling Yard, BNR Railyard, and Former Swamp/Lakebed. Figure 47 in the Reference Appendix presents the number of TICs detected per sampling location (no map is associated with the semivolatile TICs). TIC concentrations ranged from 12 µg/kg (unknown compound at location 422) to 350,000 µg/kg (total extractable hydrocarbon at location 353). Complete analytical results are available in Section 7.0 of the Data Appendix.

4.2.2.3 Volatile Organic Compounds. One-hundred twenty-three (123) samples (excluding duplicates) were analyzed for VOCs. VOCs were generally detected in only a few of the analyzed samples. Graphical presentations and concentration maps of VOCs analytical results are available in the Reference Appendix. Complete analytical results, including laboratory and validation qualifiers, are presented in Section 7.0 of the Data Appendix.

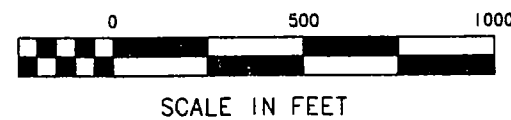
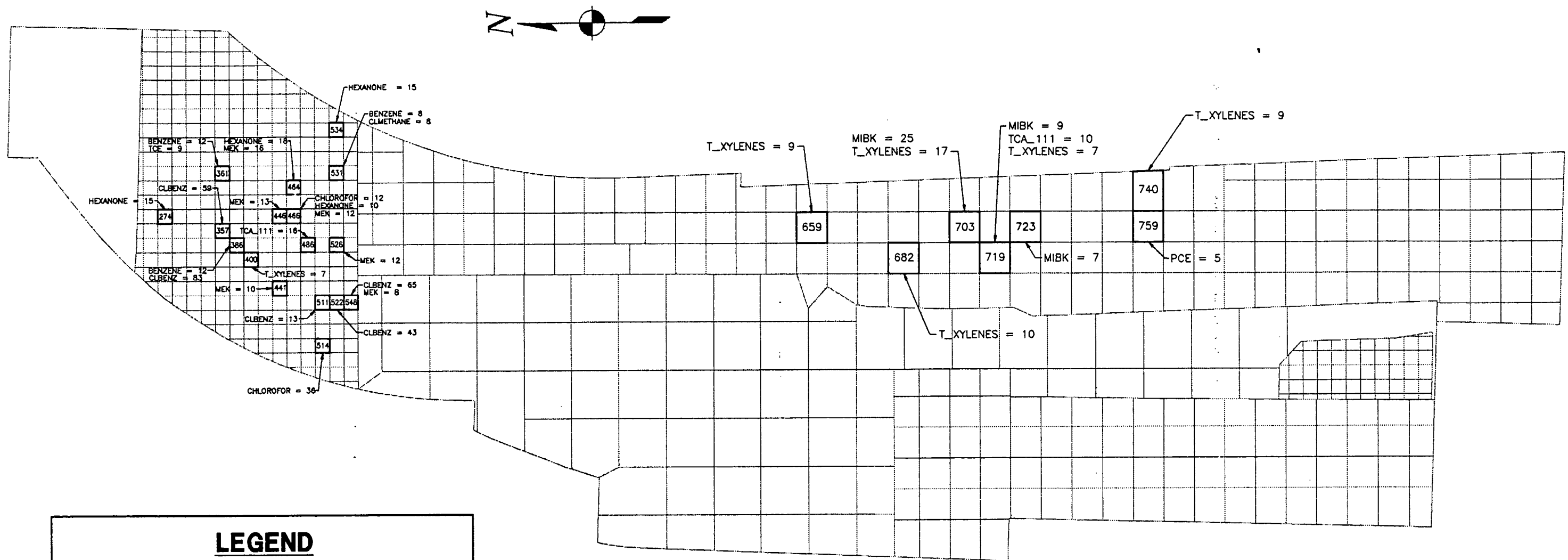
Most VOCs were undetected or only detected in less than 5 percent of the analyzed samples. Acetone, methylene chloride, and toluene were the only VOCs detected in more than 5 percent of the analyzed samples. However, those same VOCs were frequently detected in the laboratory blanks. Table SS-56 presents the number of samples collected from the STF site with VOCs detected in less than 5 percent of the analyzed samples and the maximum concentration for each detected chemical of concern. Figure SS-11 presents the locations and concentrations of these detected VOCs.

TABLE SS-56

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS
DETECTED IN LESS THAN 5 PERCENT OF SURFACE SOIL SAMPLES**

Chemical of Concern	Number of Detected Values	Maximum Concentration ($\mu\text{g}/\text{kg}$)
Benzene	3	12
Chlorobenzene	5	83
Chloroform	2	36
Chloromethane	1	J ^(a) 8
2-Hexanone	4	18
2-Butanone (MEK)	6	16
4-Methyl-2-pentanone (MIBK)	3	25
Tetrachloroethene	1	J 5
1,1,1-Trichloroethane	2	16
Trichloroethene	1	J 9
Xylenes (total)	6	17

(a) J - Laboratory qualifier signifying estimated concentration.



NOTE:
ALL CONCENTRATIONS ARE IN ug/kg.

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

**CONCENTRATIONS OF
VOLATILE ORGANIC COMPOUNDS
SURFACE SOIL INVESTIGATION**

916055.02/P1SK309

FIGURE SS-11

For each VOC detected in more than 5 percent of the collected samples (except methylene chloride), a summary of the statistical results and the number of values detected within each class interval are presented in the following subsections. A brief description of the distribution of each VOC is also included. The terms low, moderate, and high, when referring to site concentrations, are used relative to concentrations reported in other samples collected from the STF site.

Methylene Chloride. Methylene chloride was detected in all 123 samples. Methylene chloride was analyzed for in 123 samples and detected in all. However, 97 percent of all results were flagged with a B indicating methylene chloride was also detected in laboratory blanks. Eighty percent (99 samples) of the laboratory analyses were submitted for independent data validation. Sixty-five (65) of the 99 samples were qualified as estimated undetected (UJ) at the indicated concentration. Fourteen (14) of the remaining concentrations were qualified as estimated concentration (J). Only 18 of the reported concentrations were not assigned additional qualifiers during data validation.

Methylene chloride is a common laboratory contaminant (EPA 1986) and an evaluation of the analytical results indicates that the reported methylene chloride concentrations are probably not representative of conditions at the STF site. The spatial distribution figure (Figure 48 and Map 47 in the Reference Appendix) does not present any discernable trends, further suggesting the reported concentrations do not reflect actual site conditions.

Acetone. Acetone was detected in 43 samples, but 19 of the analyses (44%) were subsequently qualified as estimated undetected (UJ) during data validation because of acetone contamination of the laboratory blank. The statistical summary for all analyzed samples is presented in Table SS-57, and the graphical presentations are shown in Figure 49 and Map 48 of the Reference Appendix.

TABLE SS-57
STATISTICAL SUMMARY FOR ACETONE

Number of Values	Minimum Concentration ^(a) (µg/kg)	Maximum Concentration (µg/kg)	Mean Concentration (µg/kg)	Variance (µg/kg) ²	Standard Deviation (µg/kg)	95% UCL (µg/kg)
124	5	68	10	77	9	12
Number of Values Per Class Interval						
0 - <17		17 - <24		24 - <50		≥50
101		8		10		1

(a) Concentration could be equal to one-half of the detection limit.

Acetone concentrations were detected in samples collected from a few locations from all sampling units except TIP and the Airport. Sampling units exhibiting the most detected concentrations include the BNR Railyard and the Former Swamp/Lakebed. At least one high concentration of acetone was detected in each of those sampling units and the BNR Dismantling Yard and Amsted. The maximum acetone concentration, 68 µg/kg, was detected in the sample collected from location 855 in Amsted.

Toluene. Toluene was detected in 66 samples. The statistical summary for all analyzed samples is presented in Table SS-58, and the graphical presentations are shown in Figure 50 and Map 49 of the Reference Appendix.

TABLE SS-58
STATISTICAL SUMMARY FOR TOLUENE

Number of Values	Minimum Concentration ^(a) (µg/kg)	Maximum Concentration (µg/kg)	Mean Concentration (µg/kg)	Variance (µg/kg) ²	Standard Deviation (µg/kg)	95% UCL (µg/kg)
118	5	220	22	1,100	33	28
Number of Values Per Class Interval						
0 - <22	22 - <44	44 - <140	≥ 140			
84	21	10	3			

(a) Concentration could be equal to one-half of the detection limit.

Toluene concentrations were detected in samples collected from the BNR Dismantling Yard, the BNR Railyard, and Amsted. Moderate to high concentrations were detected in samples collected from these three sampling units. High concentrations were also detected in samples collected from the central section of the BNR Railyard. The maximum toluene concentration, 220 µg/kg, was detected in the sample collected from location 703 in the BNR Railyard.

TICs. TICs were detected primarily in samples collected from the BNR Dismantling Yard and BNR Railyard. Figure 51 in the Reference Appendix presents the number of TICs detected per sampling location (no map is associated with the volatile TICs). One TIC each was detected in the Former Swamp/Lakebed and the Airport. TIC concentrations ranged from 5 µg/kg (unknown compound at location 626) to 560 µg/kg (aliphatic hydrocarbon C4 at location 526). Complete analytical results are available in Section 7.0 of the Data Appendix.

4.2.2.4 Pesticides/PCBs. One-hundred twenty-three (123) samples were analyzed for pesticide and PCB compounds. The following six pesticide compounds were detected in five samples collected from the STF site: aldrin, dieldrin, endosulfan sulfate, methoxychlor, 4,4-DDT, and endrin ketone.

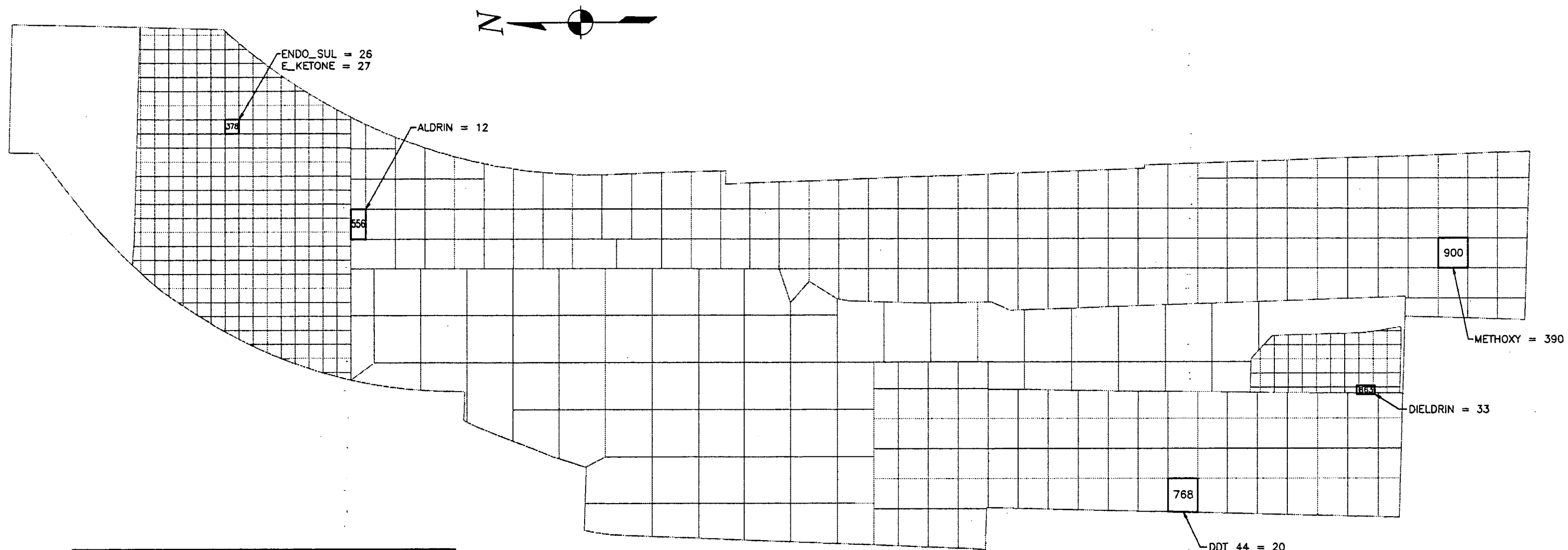
Locations and concentrations of the detected pesticides are presented in Figure SS-12. Complete analytical results are available in Section 7.0 of the Data Appendix.

Two PCB compounds, Aroclor-1254 and Aroclor-1260, were detected in 19 samples. A summary of the PCB analytical results is presented in Table SS-59, and displayed in Figure 52 in the Reference Appendix. Total PCB concentrations were calculated using only detected values. PCBs were only detected in samples collected from the BNR Dismantling Yard and BNR Railyard. Twelve of the 19 locations where PCBs were detected exhibited a detected total PCB concentration < 1 mg/kg.

The three highest concentrations (42 mg/kg, 17 mg/kg, and 15 mg/kg) were detected in samples collected from the northern quarter of BNR Railyard; two of the three locations are adjacent locations. Based on known historical activities (see Figure SS-1), these sampling locations do not appear to have been in a location where disposal of oil containing PCBs would be expected. However, the location could have been an unknown waste oil disposal site or possibly where leaking electrical transformers were located.

4.2.2.5 Dioxins and Furans. Dioxins and furans were detected at low concentrations (< 1 µg/kg) in five samples collected from the BNR Dismantling Yard and BNR Railyard. Analytical results are presented in Table SS-60 and Section 7.0 of the Data Appendix.

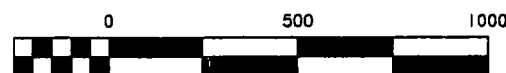
The toxicity equivalency factor (TEF) is the value that, when multiplied by the associated concentration, represents an equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Concentrations are reported when



LEGEND

ALDRIN = 12
 556 12 ug/kg ALDRIN
 DETECTED AT LOCATION 556

ALDRIN	-	ALDRIN
DIELDRIN	-	DIELDRIN
DDT_44	-	4,4-DDT
METHOXY	-	METHOXYCHLOR
ENDO_SUL	-	ENDOSULFAN SULFATE
E_KETONE	-	ENDRIN KETONE



SCALE IN FEET

NOTE:

ALL CONCENTRATIONS ARE IN ug/kg.

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SOUTH TACOMA FIELD
 TACOMA, WA

**CONCENTRATIONS OF
 PESTICIDE COMPOUNDS
 SURFACE SOIL INVESTIGATION**

916055.02/P1SK310

FIGURE SS-12

TABLE SS-59

**SUMMARY OF PCB ANALYTICAL RESULTS (mg/kg)
FOR SURFACE SOIL SAMPLES**

Location Number	Aroclor-1254 ^(a,b)	Aroclor-1260 ^(a,b)	Total PCBs ^(c)
259	0.37	U 0.18	0.37
328	3.0	U 1.8	3.0
353	U 0.18	0.35	0.35
415	0.82	U 0.17	0.82
457	0.38	U 0.17	0.38
471	0.24	U 0.21	0.24
491	U 0.20	0.44	0.44
496	0.32	U 0.17	0.32
503	9.0	U 4.2	9.0
541	2.6	U 2.1	2.6
543	0.2	U 0.2	0.2
558	0.17	U 0.17	0.17
562	15 J3	U 4.1 UJ	15
574	0.42	U 0.2	0.42
579	17	U 4.3	17
586	42	U 8.3	42
636	0.37	U 0.18	0.37
682	0.54	U 0.54	0.54
703	0.71	1.0	1.7

(a) Each analyte column has three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is the reported concentration; and 3) the right margin contains the data validation qualifiers.

(b) Organic Data Qualifiers (also see Data Appendix):

U - Analyte was analyzed for, but not detected, at the undetected concentration.

UJ - The analyte was analyzed for and was not present above the indicated concentration. The value is an estimate of the detection level.

J3 - Holding times not met; indicates low bias.

(c) The total concentration for each sample location was calculated by summing detected concentrations (see Data Appendix for complete analytical results).

TABLE SS-60

SUMMARY OF DIOXIN/FURAN ANALYTICAL RESULTS, ppt^(a)
FOR SURFACE SOIL SAMPLES

Chemical Name	TEF (b)	LOCATION 357				LOCATION 386				LOCATION 619				LOCATION 952				LOCATION 953			
		Concentration (c,d)	TCDD (e) Equivalent	EMPC (c,d,f)	TCDD (e) Equivalent	Concentration (c,d)	TCDD (e) Equivalent	EMPC (c,d,f)	TCDD (e) Equivalent	Concentration (c,d)	TCDD (e) Equivalent	EMPC (c,d,f)	TCDD (e) Equivalent	Concentration (c,d)	TCDD (e) Equivalent	EMPC (c,d,f)	TCDD (e) Equivalent	Concentration (c,d)	TCDD (e) Equivalent	EMPC (c,d,f)	TCDD (e) Equivalent
Dioxins:																					
2,3,7,8-tetrachlorodibenzo-p-dioxin	1	EMPC	NA (g)	2.2 J4	2.2	EMPC	NA	2.8 J4	2.8	ND (h)	NA	NA	NA	ND	NA	NA	NA	ND	NA	NA	NA
1,2,3,7,8-pentachlorodibenzo-p-dioxin	0.5	EMPC	NA	1.9 J4	0.95	3.0	1.5	NA	NA	3	2	NA	NA	1	0.50	NA	NA	ND	NA	NA	NA
1,2,3,4,7,8-hexachlorodibenzo-p-dioxin	0.04	EMPC	NA	1.9 J4	0.076	EMPC	NA	2.6 J4	0.10	ND	NA	NA	NA	2	0.08	NA	NA	2	0.08	NA	NA
1,2,3,6,7,8-hexachlorodibenzo-p-dioxin	0.04	EMPC	NA	3.1 J4	0.12	3.3	0.13	NA	NA	EMPC	NA	4 J4	0.2	3	0.1	NA	NA	4	0.2	NA	NA
1,2,3,7,8,9-hexachlorodibenzo-p-dioxin	0.04	EMPC	NA	PR 4.8 J4	0.19	PR 5.7	0.23	NA	NA	6	0.2	NA	NA	3	0.1	NA	NA	6	0.2	NA	NA
1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin	0.001	42.9	0.0429	NA	NA	26.6	0.0266	NA	NA	20	0.02	NA	NA	60	0.06	NA	NA	120	0.120	NA	NA
octachlorodibenzo-p-dioxin	0.001	B 282	0.282	NA	NA	B 123	0.123	NA	NA	60	0.060	NA	NA	B 630	0.63	NA	NA	B 1000	1.000	NA	NA
Furans:																					
2,3,7,8-tetrachlorodibenzofuran	0.1	B 61.1	6.11	NA	NA	B 86.2	8.62	NA	NA	160	16.0	NA	NA	20	2.0	NA	NA	8	0.8	NA	NA
1,2,3,7,8-pentachlorodibenzofuran	0.1	EMPC	NA	8.4 J4	0.84	13.4	1.34	NA	NA	20	2.0	NA	NA	3	0.3	NA	NA	EMPC	NA	2 J4	0.2
2,3,4,7,8-pentachlorodibenzofuran	0.1	13.7	1.37	NA	NA	18.7	1.87	NA	NA	30	3.0	NA	NA	4	0.4	NA	NA	EMPC	NA	3 J4	0.3
1,2,3,4,7,8-hexachlorodibenzofuran	0.01	PR 21.6	0.216	NA	NA	PR 30.3	0.303	NA	NA	40	0.40	NA	NA	8	0.08	NA	NA	6	0.06	NA	NA
1,2,3,6,7,8-hexachlorodibenzofuran	0.01	6.8	0.068	NA	NA	11.6	0.116	NA	NA	20	0.20	NA	NA	2	0.02	NA	NA	2	0.02	NA	NA
2,3,4,6,7,8-hexachlorodibenzofuran	0.01	B,PR 11.3	0.113	NA	NA	B,PR 16.1	0.161	NA	NA	20 UJ	NA	NA	NA	B 8	0.08	NA	NA	EMPC	NA	B 7 J4	0.07
1,2,3,7,8,9-hexachlorodibenzofuran	0.01	EMPC	NA	0.65 J4	0.0065	ND	NA	NA	NA	EMPC	NA	2 J4	0.02	ND	NA	NA	NA	ND	NA	NA	NA
1,2,3,4,6,7,8-heptachlorodibenzofuran	0.001	B 26.5	0.0265	NA	NA	B 41.9	0.0419	NA	NA	40	0.040	NA	NA	10	0.010	NA	NA	30	0.030	NA	NA
1,2,3,4,6,7,8,9-heptachlorodibenzofuran	0.001	2.9	0.0029	NA	NA	6.3	0.0063	NA	NA	5	0.005	NA	NA	ND	NA	NA	NA	2	0.002	NA	NA
octachlorodibenzofuran	0.001	B 34.6	0.0346	NA	NA	B 103	0.103	NA	NA	EMPC	NA	20 J4	0.020	40	0.040	NA	NA	80	0.080	NA	NA
Total Dioxins:																					
tetrachlorodibenzo-p-dioxin	0.01	26.2	0.262	31.8 J4	0.319	24.0	0.24	32.6 J4	0.326	40	0.40	50 J4	0.50	Q 30	0.30	NA	NA	20	0.20	20	0.20
pentachlorodibenzo-p-dioxin	0.005	Q 13.1	0.0656	Q 29.1 J4	0.146	16.7	0.0836	36.9 J4	0.184	20	0.10	50 J4	0.25	30	0.15	30 J4	0.15	10	0.050	20	0.10
hexachlorodibenzo-p-dioxin	0.0004	22.4	0.00896	40.2 J4	0.0161	28.8	0.0116	41.5 J4	0.0166	40	0.016	50 J4	0.020	40	0.016	40 J4	0.016	60	0.024	60	0.024
heptachlorodibenzo-p-dioxin	0.00001	77.0	0.00077	NA	NA	60.5	0.000601	NA	NA	20	0.00020	30 J4	0.00030	190	0.00190	NA	NA	310	0.00310	NA	NA
Total Furans:																					
tetrachlorodibenzofuran	0.001	324	0.324	326 J4	0.326	361	0.361	386 J4	0.386	860	0.860	900 J4	0.900	Q 80	0.080	Q 100 J4	0.100	Q 40	0.040	Q 60 J4	0.060
pentachlorodibenzofuran	0.001	122	0.122	139 J4	0.139	166	0.166	176 J4	0.176	190	0.190	320 J4	0.320	Q 50	0.050	Q 50 J4	0.050	Q 30	0.030	Q 60 J4	0.060
hexachlorodibenzofuran	0.0001	65.9	0.00659	73.1 J4	0.00731	89.0	0.0089	98.8 J4	0.00988	120	0.0120	130 J4	0.0130	40	0.0040	NA	NA	50	0.0050	60	0.0060
heptachlorodibenzofuran	0.00001	65.4	0.000654	NA	NA	68.8	0.000688	78.4 J4	0.00078	60	0.00060	70 J4	0.00070	20	0.00020	30 J4	0.00030	80	0.00080	NA	NA

(a) Parts per trillion.
(b) TEF = Toxicity Equivalency Factor.
(c) Under each location number, the concentration and EMPC columns have three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is the reported concentration; and 3) the right margin contains the data validation qualifiers.
(d) Dioxin/Furan Data Qualifiers:
B - Analyte found in associated laboratory blank as well as in sample.
J - Estimated value.
J4 - Estimated value, other QC outside control limits, bias not readily determined.
PR - Poorly resolved gas chromatograph peak.
U - Analyte was analyzed for, but not detected at the indicated concentration.
Q - Quantitative interference; reported concentration may be questionable.
(e) TCDD = 2,3,7,8-Tetrachlorodibenzo-p-dioxin.
(f) EMPC = Estimated maximum possible concentration.
(g) NA = Not applicable.
(h) ND = Not detected.

quality criteria have been met. In instances when criteria have not been met, the estimated maximum possible concentration is presented. Total dioxins and total furans are calculated from all concentrations detected for each isomer in the homologue.

Concentrations of dioxins and furans were relatively low (i.e., $< 1 \mu\text{g/kg}$). The highest concentration (measured as 2,3,7,8-TCDD equivalent) was detected for 2,3,7,8-tetrachlorodibenzofuran at 15.0 nanograms/kilogram (ng/kg) (parts per trillion) in the sample collected from location 619 in the BNR Railyard.

The greatest total cumulative TCDD equivalent (includes dioxins and furans) was also detected at location 619, followed by locations 386 and 357 in the BNR Dismantling Yard, and locations 953 and 952 in the BNR Railyard.

Dioxins and furans are ubiquitous in the environment and have a variety of anthropogenic sources (ChemRisk 1991). In one study performed in Britain, concentrations of 2,3,7,8-TCDD in soil samples collected from industrial areas ranged from $< 0.5 \text{ ng/kg}$ to 4.2 ng/kg , with a mean of 0.7 ng/kg and a standard deviation of 1.2 ng/kg (Creaser et al. 1990). Cleanup levels in the United States for 2,3,7,8-TCDD, in general, range from $1 \mu\text{g/kg}$ to $> 20 \mu\text{g/kg}$, although a few cleanup levels have been established at levels $< 1 \mu\text{g/kg}$ (ChemRisk et al. 1991).

TCDD equivalent concentrations at STF are near or less than the mean TCDD concentration from soil in industrial areas as reported by Creaser et al. (1990). TCDD equivalent concentrations at STF are well below $1 \mu\text{g/kg}$, the typical low range of U.S. cleanup levels for 2,3,7,8-TCDD.

4.2.3 Summary of Onsite Surface Soil Organic Analytical Results

This section presents a summary of the organic analytical results for each of the surface soil sampling units.

4.2.3.1 BNR Dismantling Yard. The presence of organic chemicals of concern in the BNR Dismantling Yard would be expected based on the industrial activities that have been conducted in this sampling unit (see Section 1.4.1). In particular, PAHs were detected in many samples collected from the BNR Dismantling Yard. PAHs in the environment are largely the result of incomplete combustion of carbonaceous material. Other sources could also include wood treatment operations. Both these sources would be expected at a major railroad equipment repair facility.

The most elevated PAH concentrations were detected in samples collected from along the eastern edge of the sampling unit, in the same location as the existing railroad line, and in the eastern section. Other locations where elevated concentrations were detected include the gantry crane area (adjacent to Tacoma City Light) and the storehouse (legend numbers 2 and 6, respectively, in Figure SS-1), and in the vicinity of the rubbish track corridor and storage yard (legend numbers 11 and 10, respectively, in Figure SS-1). Elevated concentrations of PAHs were also detected in scattered locations in the BNR Dismantling Yard. Because the BNR Dismantling Yard was a location for open burning, elevated concentrations of PAHs would be expected to be detected in samples collected from this unit. However, in the area noted as the burn pit (legend number 8), evidence of elevated PAH concentrations or dioxins and furans was not apparent.

Semivolatile and volatile organic compounds were analyzed in only 20 percent of the samples collected from this sampling unit, and general conclusions about the presence and potential source of these chemicals are difficult to determine. Semivolatile organic compounds were detected in samples collected throughout the site. VOCs were detected primarily in the central and western sections of the site. The presence of methylene chloride, acetone, and toluene in some samples collected from the BNR Dismantling Yard is likely due to laboratory contamination and may not accurately reflect conditions in site soil.

Pesticides were detected in only one sample collected from the BNR Dismantling Yard. PCBs detected in samples collected from the BNR Dismantling Yard were

located along the eastern edge of the site near the existing railroad line and in the vicinity of the storage yard and rubbish track corridor.

4.2.3.2 BNR Railyard. The BNR Railyard was the location for many of the railroad repair shops and maintenance facilities. Elevated levels of organic chemicals would be expected in this unit based on historical activities as well as from the incomplete combustion of fossil fuels used in heating and as locomotive fuel.

Elevated concentrations of PAHs were detected in samples collected throughout the BNR Railyard. In particular, elevated concentrations were detected in soil samples collected along the eastern edge in the north-central section of the sampling unit, near the existing railroad line and in the vicinity of the blacksmith shop, car casting platform, freight repair shed, and wheel shop (legend numbers 14, 19, 30, and 32, respectively, in Figure SS-1). Other locations where elevated concentrations of PAHs were detected in BNR Railyard soil include the area near the finished lumber shed (legend number 31, Figure SS-1) and in the southern section of the BNR Railyard, which included the machine shop; boiler, tin tank, and copper shop; south machine shop; trash burner; blacksmith shop; iron and steel storage; turntable; and railroad cleanout area (legend numbers 44, 46, 47, 48, 49, 50, 51, and 54, respectively, in Figure SS-1).

Semivolatile and volatile organic compounds were detected in samples collected throughout the BNR Railyard. Specifically, semivolatile organic compounds were detected in samples collected from scattered locations throughout the BNR Railyard. Elevated levels were more likely to be detected in samples collected from the central and southern sections of the BNR Railyard. VOCs, except for acetone and methylene chloride, were typically detected in samples collected in the central section of the BNR Railyard. Acetone and methylene chloride were typically detected in samples collected from the northern and southern sections of the BNR Railyard. The presence of methylene chloride, and to a lesser extent, acetone and toluene, in some samples collected from the BNR Railyard is likely due to laboratory contamination and may not accurately reflect conditions in site soil.

Pesticides were detected in samples collected from two widely spaced locations, one from the northern end and one from the southern end of the BNR Railyard. PCBs were detected in samples collected from the northern and central sections of the site. PCB concentrations in the northern section were the most elevated compared to all samples collected from the STF site. These samples were collected from the vicinity of the rubbish track corridor, and the sandblast and blacksmith shops (legend numbers 11, 13, and 14, respectively, in Figure SS-1). The elevated concentrations may be explained by the potential disposal of PCB-contaminated oils in this area or possibly the leaking of electrical equipment containing PCB fluids.

4.2.3.3 Amsted. Amsted was the former site of the Griffin Wheel Foundry Company. Three underground storage tanks were removed from the site during demolition of the brass foundry building (Kennedy/Jenks/Chilton 1990). Subsequent investigations revealed the presence of oil in an onsite well (Kennedy/Jenks Consultants 1991b).

Sampling during this surface soil investigation revealed the presence of elevated concentrations of PAHs in samples collected from the northern section of the site, particularly in the eastern portion. A railroad line is located in this vicinity, adjacent to the former foundry. The tanks were located directly north of the former foundry (legend number 56 in Figure SS-1).

Other semivolatile organic compounds (except TICs) and PCBs were not detected in samples collected from this sampling unit. Pesticides were detected in one sample collected from the western edge of the unit. Acetone, toluene, and methylene chloride were detected in some samples. The detection of VOCs, particularly methylene chloride, is likely the result of laboratory contamination and may not accurately reflect conditions in site soil.

4.2.3.4 Former Swamp/Lakebed. The Former Swamp/Lakebed was used for disposal of various waste material, including foundry wastes. PAHs were detected in samples collected throughout this sampling unit, but often in the central section of the sampling unit in the vicinity of the Atlas Foundry disposal area, as well as

along the eastern border (adjacent to Amsted and TIP) and in the vicinity of the Fick Foundry disposal area (see Figure SS-1).

Semivolatile and volatile organic compounds were detected in a few samples collected from scattered locations in this sampling unit. Pesticides were detected in only one sample. PCBs were not detected in samples collected from the Former Swamp/Lakebed.

4.2.3.5 Airport. Low to moderate concentrations of PAHs were generally detected in samples collected from this sampling unit. However, elevated concentrations of some PAHs were detected in samples collected from the northern and northeastern section of the sampling unit, adjacent to the BNR Dismantling Yard and BNR Railyard. Elevated PAH concentrations in this area of the sampling unit are not unexpected based on nearby historical industrial operations. The storage yard from the BNR Dismantling Yard extends into the northwestern end of the Airport, and the Car Shops area in the BNR Railyard is on the boundary of the Airport (see Figure SS-1). Operations and disposal of waste materials from the Car Shops area is a potential source of some of the PAHs detected in soil samples collected from the Airport.

Semivolatile and volatile organic contaminants were detected in samples collected from scattered locations at the Airport. The most commonly detected chemical was methylene chloride. However, methylene chloride is a common laboratory contaminant, and it was detected in most laboratory blanks. The occurrence of methylene chloride in some samples collected from the Airport is likely the result of laboratory contamination and may not accurately represent conditions in the site soil.

Pesticides and PCBs were not detected in samples collected from the Airport.

4.2.3.6 TIP. TIP includes portions of the Griffin Wheel Foundry Company area and the Car Shops. Much of TIP area is covered with buildings and pavement and was inaccessible for surface soil sampling. Elevated PAH concentrations were detected

in samples collected from the northwestern portion of TIP. This area is in the vicinity of the oil tanks and former iron foundry (legend numbers 41 and 53, respectively, in Figure SS-1).

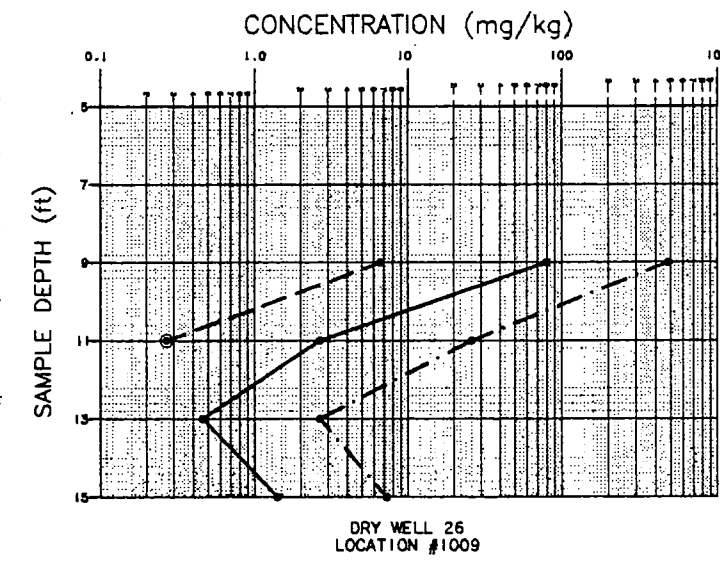
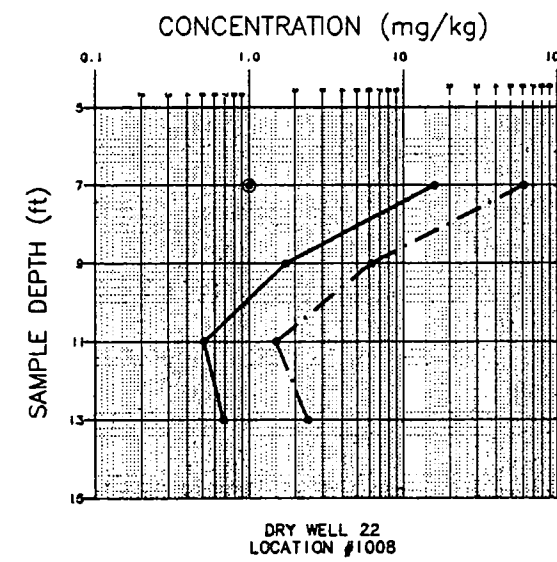
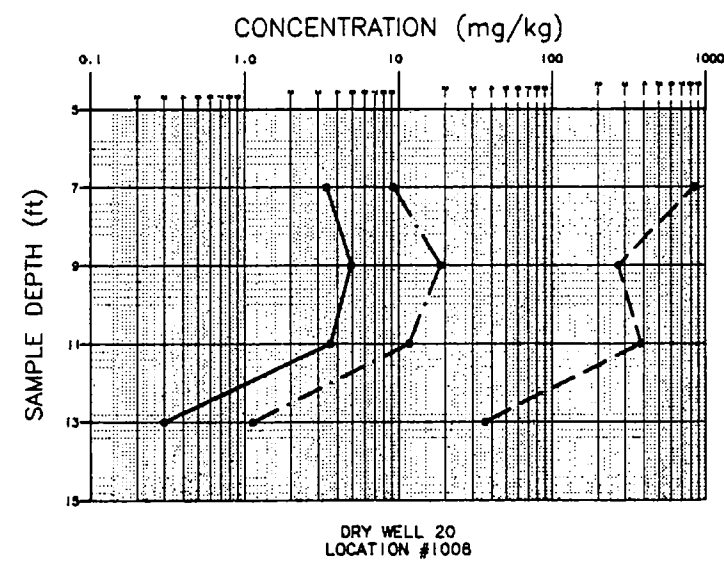
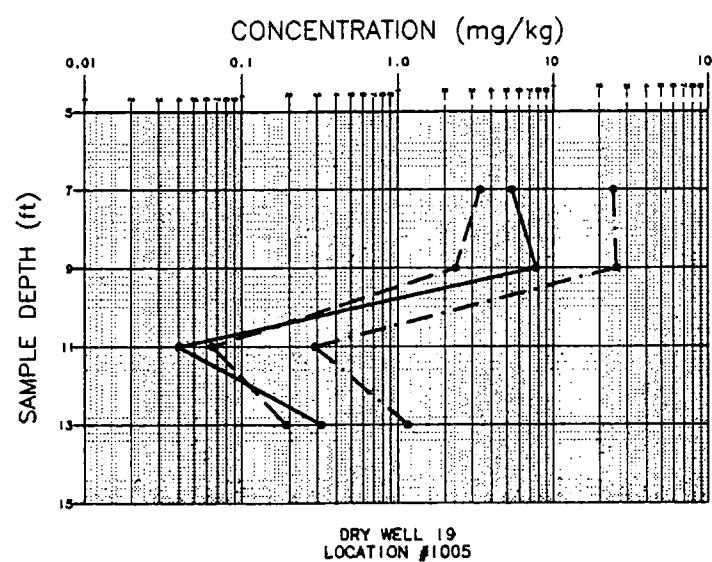
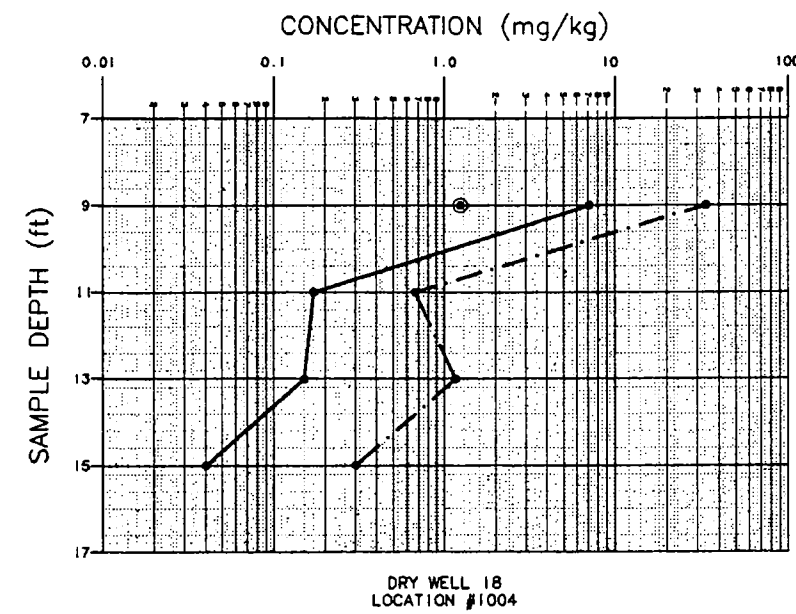
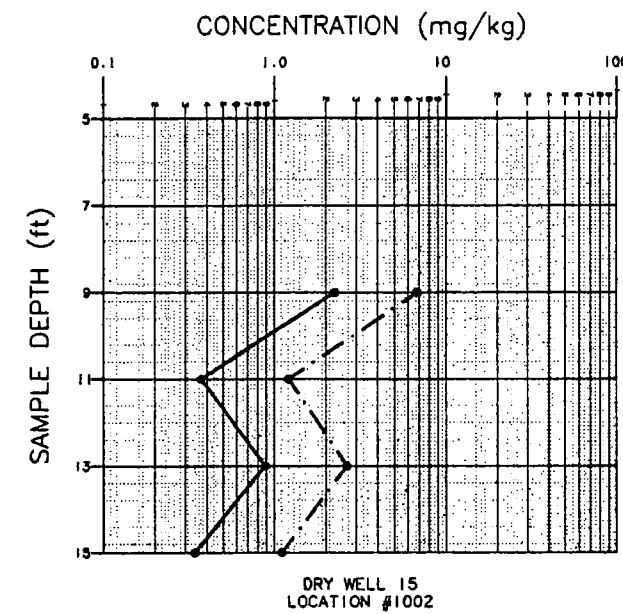
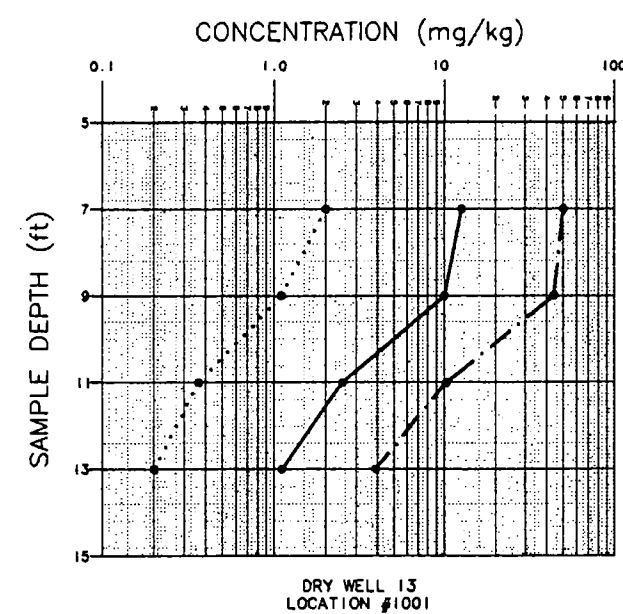
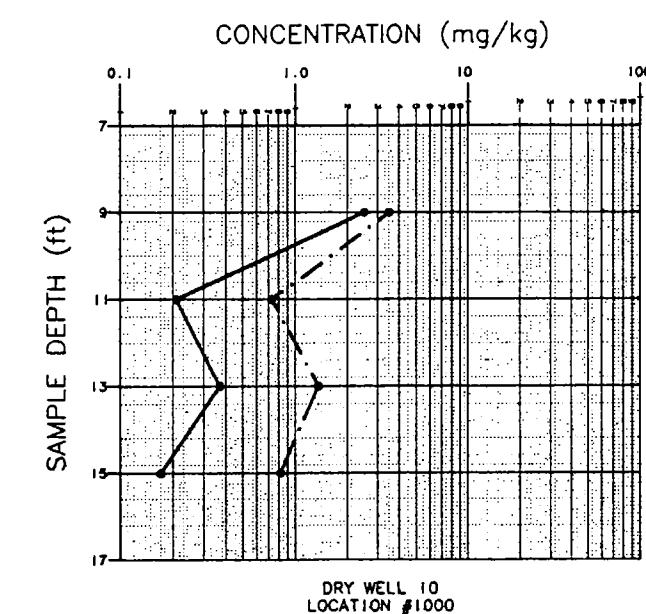
Semivolatile and volatile organic compounds were usually not detected or detected at low to moderate concentrations in samples collected from TIP. Pesticides and PCBs were not detected in samples collected from TIP.

4.2.4 Summary of Tacoma City Light Subsurface Organic Analytical Results

4.2.4.1 PAHs. Table SS-61 presents a summary of the total PAHs and total probable carcinogenic PAHs analytical results. Figure SS-13 presents the change in concentration of total PAHs and total probable carcinogenic PAHs with depth in each dry well. Complete analytical results are presented in Section 7.0 of the Data Appendix.

One or more PAH compounds were detected in each of the 32 samples collected. Detected concentrations of total PAHs (undetected values were included at one-half the detection limit) ranged from 0.30 mg/kg (sample collected at 15-foot depth from DW-18 and at 11-foot depth from DW-19) to 490 mg/kg (sample collected at 9-foot depth from DW-26). PAH concentrations typically decreased with overall depth. Generally, the total concentrations in samples collected from the shallowest locations were 1-2 orders of magnitude greater compared to samples collected from the deepest locations.

4.2.4.2 Semivolatile Organic Compounds. Table SS-61 also presents a summary of the analytical results for semivolatile organic compounds. Semivolatile organic compounds were detected in all eight dry wells. Detected semivolatile organic compounds include 1,3-dichlorobenzene; 1,4-dichlorobenzene; 1,2,4-trichlorobenzene; 2-methylnaphthalene; dibenzofuran; diethylphthalate; n-nitrosodiphenylamine; pentachlorophenol; carbazole; di-n-butylphthalate; 3,3-dichlorobenzidine; and bis(2-ethylhexyl)phthalate.



LEGEND

- ALDRIN
- TOTAL PROBABLE CARCINOGENIC PAHs
- - - - - TOTAL PAHs
- - - - - TOTAL PCBs
- ⊙ PCBs NOT DETECTED BELOW THIS DEPTH

Kennedy/Jenks Consultants

SOUTH TACOMA FIELD
TACOMA, WA

**DRY WELL CONCENTRATIONS
WITH DEPTH**

916055.02/P1SK114A

FIGURE SS-13

TABLE SS-61

**SUMMARY OF PAH AND SEMIVOLATILE ORGANIC COMPOUND ANALYTICAL RESULTS
FOR TACOMA CITY LIGHT DRY WELL SUBSURFACE SOIL SAMPLES**

Dry Well (Depth in feet)	PAHs(mg/kg) ^(a,b)		Semivolatiles (ug/kg) ^(a,b)											
	Total Probable Carcinogenic	Total PAHs	1,3-Dichloro- benzene	1,4-Dichloro- benzene	1,2,4-Trichloro- benzene	2-Methyl- naphthalene	Dibenzo- furan	Diethyl- phthalate	N-nitrosodi- phenylamine	Pentachloro- phenol	Carbazole	Di-n-butyl- phthalate	3,3-Dichloro- benzidine	Bis(2-ethylhexyl)- phthalate
DW-10														
(9)	2.5	3.5	—	—	—	J 140	—	—	—	—	—	—	—	BJ 370
(11)	0.21	0.73	—	—	—	—	—	—	—	—	—	—	—	—
(13)	0.46	1.3	—	—	—	—	—	—	—	—	—	—	—	—
(15)	0.17	0.82	—	—	—	—	—	—	—	—	—	—	—	—
DW-13														
(7)	12	50	—	—	—	J 3,500	—	—	—	—	12,000 J4	—	—	—
(9)	10	45	—	—	—	2,400 J4	2,700	—	—	—	—	—	—	—
(11)	2.6	10	—	—	—	J 430	J 590	—	—	—	880	—	—	B 800
(13)	1.1	3.9	—	—	—	—	—	—	—	—	—	—	—	—
DW-15														
(9)	2.3	6.9	—	—	—	—	—	—	—	—	J 210	—	—	—
(11)	0.37	1.2	—	—	—	—	—	—	—	—	—	—	—	—
(13)	0.89	2.6	—	—	—	—	—	—	—	—	J 120	—	—	B 2,000
(15)	0.34	1.1	—	—	—	—	—	—	—	—	—	—	—	—
DW-18														
(9)	7.2	33	—	—	—	J 240	—	—	J 360 J4	—	—	—	—	—
(11)	0.17	0.68	—	—	—	—	—	—	—	—	—	560 J4	—	—
(13)	0.15	1.1	—	—	—	—	—	4,600	—	—	—	1,400	—	B 2,200
(15)	0.04	0.30	—	—	—	—	—	—	—	—	—	550 J4	—	—
DW-19														
(7)	5.4	25	—	—	—	J 300	—	—	—	—	—	—	—	—
(9)	7.6	25	—	—	—	J 420	—	—	—	—	—	B 10,000	—	—
(11)	0.04	0.30	—	—	—	—	—	—	—	—	—	—	—	—
(13)	0.32	1.4	—	—	—	—	—	—	—	—	2,000	—	—	—
DW-20														
(7)	3.2	9.1	J 1,700	9,200	—	—	—	J 1,500	—	—	—	—	—	—
(9)	4.9	18	J 1,600	6,300	J 230	—	—	J 1,400	—	—	—	—	—	—
(11)	3.6	12	—	—	—	—	—	—	—	—	—	—	—	—
(13)	0.30	1.2	—	—	—	—	—	—	—	—	—	—	—	B 3,500
DW-22														
(7)	16	61	—	—	—	J 730	—	J 230	—	—	5000	—	—	—
(9)	1.7	6.3	—	—	—	—	—	—	—	—	—	—	—	—
(11)	0.51	1.5	—	—	—	—	—	J 56	—	—	J 160 J4	J 260	—	—
(13)	0.69	2.4	—	—	—	—	—	J 140	—	—	—	4700	—	—

TABLE SS-61

**SUMMARY OF PAH AND SEMIVOLATILE ORGANIC COMPOUND ANALYTICAL RESULTS
FOR TACOMA CITY LIGHT DRY WELL SUBSURFACE SOIL SAMPLES**

Dry Well (Depth in feet)	PAHs(mg/kg) ^(a,b)		Semivolatiles (ug/kg) ^(a,b)											
	Total Probable Carcinogenic	Total PAHs	1,3-Dichloro- benzene	1,4-Dichloro- benzene	1,2,4-Trichloro- benzene	2-Methyl- naphthalene	Dibenzo- furan	Diethyl- phthalate	N-nitrosodi- phenylamine	Pentachlor- phenol	Carbazole	Di-n-butyl- phthalate	3,3-Dichloro- benzidine	Bis(2-ethylhexyl)- phthalate
DW-26														
(9)	80	490	—	—	—	J 3,800	15,000	—	23,000 J4	150,000	10,000 J4	—	J 22,000 J4	—
(11)	2.7	26	—	—	—	—	J 1,300	—	J 3,600 J4	J 15,000	8,200 J4	—	—	—
(13)	0.46	2.7	—	—	—	—	—	—	—	J 300	—	—	—	—
(15)	1.41	7.2	—	—	—	—	J 90	—	—	J 300	800	—	—	—

(a) Each analyte column has three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is detected concentration; and 3) the right margin contains the data validation qualifiers.

(b) Organic Data Qualifiers (also see Data Appendix):

J3 - Estimated value. Holding times not met; indicates low bias for most analytes.

J4 - Estimated value. Other QC outside control limits; bias not readily determined.

— - Undetected value (see Data Appendix for detection limits and associated qualifiers).

The maximum detected semivolatile organic compound concentration was 150,000 $\mu\text{g/kg}$ of pentachlorophenol in the sample collected at the 9-foot depth from DW-26. Pentachlorophenol was detected in only four samples, but they were all from DW-26. In general, for semivolatile organic compounds that were detected in more than one sample from a dry well, concentrations decreased with depth.

DW-10, DW-15, and DW-19 exhibited the fewest number of detected semivolatile organic compounds. Samples collected from DW-26 had the highest number of detected chemicals. These concentrations were typically detected at higher concentrations compared with concentrations of other compounds detected at similar depths in other dry wells, particularly the shallowest horizons where concentrations were approximately 1 order of magnitude greater.

2-Methylnaphthalene and carbazole were the most frequently detected semivolatile organic compounds. These compounds were detected in 9 and 10 samples, respectively (approximately 30 percent of the samples analyzed). All other compounds were detected in six or fewer samples (less than 19 percent of the samples analyzed).

Analytical results for TICs from samples collected from Tacoma City Light dry wells are presented in Section 7.0 of the Data Appendix. Generally, these compounds were aliphatic or cyclic hydrocarbons and probable degradation products or metabolites of hydrocarbon compounds. The lowest detected concentration was 130 $\mu\text{g/kg}$ for aliphatic hydrocarbon C23 detected in the sample collected at the 15-foot depth from DW-15. The highest detected concentration was 100,000 $\mu\text{g/kg}$ for aliphatic hydrocarbon C16 detected in the sample collected at the 13-foot depth from DW-22.

4.2.4.3 Volatile Organic Compounds. Table SS-62 presents a summary of the analytical results for VOCs. Complete analytical results are presented in Section 7.0 of the Data Appendix. VOCs were detected in samples collected from all eight dry wells. Detected VOCs include methylene chloride, acetone, 2-butanone, trichloroethene, benzene, 2-hexanone, tetrachloroethene, toluene, chlorobenzene,

TABLE SS-62

**SUMMARY OF ORGANIC ANALYTICAL RESULTS
FOR TACOMA CITY LIGHT DRY WELL SUBSURFACE SOIL SAMPLES**

Dry Well (Depth in feet)	Volatiles (ug/kg) ^(a,b)										Pesticides (ug/kg) ^(a,b)	PCBs (ug/kg) ^(a,b)
	Methylene Chloride	Acetone	2-Butanone	Trichloro- ethene	Benzene	2-Hexanone	Tetrachloro- ethene	Toluene	Chloro- benzene	Xylenes	Aldrin	Total
DW-10												
(9)	—	—	15	—	—	51	—	—	—	310	—	—
(11)	—	64	—	—	—	—	—	—	—	—	—	—
(13)	—	30 J4	—	—	—	—	—	—	—	—	—	—
(15)	—	40 J4	—	—	—	—	—	—	—	—	—	—
DW-13												
(7)	—	B 100	33	—	—	—	—	110	—	130	2,000	—
(9)	—	86 J4	—	—	—	—	—	J 9	—	J 6	1,100	—
(11)	—	—	—	—	—	—	—	—	—	—	360	—
(13)	—	100 J4	12 J4	—	—	—	—	—	—	—	200	—
DW-15												
(9)	—	—	—	—	—	—	—	—	—	—	—	—
(11)	—	24 J4	—	—	—	—	—	—	—	—	—	—
(13)	—	—	—	—	—	—	17	J 6	—	90	—	—
(15)	—	23 J4	—	—	—	—	—	—	—	—	—	—
DW-18												
(9)	—	29	—	—	—	—	—	J 6	31	61	—	1,240
(11)	—	—	J 9	—	—	J 6	—	—	—	—	—	—
(13)	—	J 11	J 7	—	—	—	—	—	—	—	—	—
(15)	—	—	—	—	—	—	—	—	—	—	—	—

TABLE SS-62

**SUMMARY OF ORGANIC ANALYTICAL RESULTS
FOR TACOMA CITY LIGHT DRY WELL SUBSURFACE SOIL SAMPLES**

Dry Well (Depth in feet)	Volatiles (ug/kg) ^(a,b)										Pesticides (ug/kg) ^(a,b)	PCBs (ug/kg) ^(a,b)
	Methylene Chloride	Acetone	2-Butanone	Trichloro- ethene	Benzene	2-Hexanone	Tetrachloro- ethene	Toluene	Chloro- benzene	Xylenes	Aldrin	Total
DW-19												
(7)	—	58 J4	—	—	—	—	—	13	J 11	330	—	3,200
(9)	—	12 J4	—	—	—	—	—	—	—	370	—	2,300
(11)	—	50 J4	—	—	—	—	—	—	—	—	—	—
(13)	—	51 J4	—	—	—	—	—	—	—	—	—	190
DW-20												
(7)	—	—	—	—	J 950 J4	—	—	—	59,000 J4	J 1,500 J4	—	840,000 J4
(9)	—	—	—	J 250 J3	J 380 J3	—	—	—	13,000 J3	—	—	270,000 J4
(11)	—	—	—	J 310 J3	J 550 J3	—	—	—	10,000 J3	J 230 J3	—	390,000 J4
(13)	—	—	—	—	—	—	—	—	13 J3	—	—	36,000
DW-22												
(7)	110 J3	—	—	—	—	—	—	41 J3	71 J3	110 J3	—	1,000
(9)	—	18 J3	—	—	—	—	—	—	—	—	—	—
(11)	—	17 J3	—	—	—	—	—	—	—	—	—	—
(13)	—	17 J3	—	—	—	—	—	—	—	—	—	—
DW-26												
(9)	—	130	58	—	—	—	—	520	—	29	—	4,600
(11)	—	28 J4	—	—	—	—	—	15	—	—	—	270
(13)	—	—	—	—	—	—	—	—	—	—	—	—
(15)	—	26	—	—	—	—	—	—	—	—	—	—

(a) Each analyte column has three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is detected concentration; and 3) the right margin contains the data validation qualifiers.

(b) Organic Data Qualifiers (also see Data Appendix):

J3 - Estimated value. Holding times not met: indicates low bias for most analytes.

J4 - Estimated value. Other QC outside control limits: bias not readily determined.

— - Undetected value (see Data Appendix for detection limits and associated qualifiers).

and xylenes. There are no consistent trends apparent in the vertical distribution of VOCs in the dry wells. In most cases, concentrations decrease with increasing depth or remain virtually unchanged. Except for DW-20, VOCs were detected at relatively low concentrations and sporadically throughout the dry wells.

The maximum detected VOC concentration was 59,000 $\mu\text{g/kg}$ of chlorobenzene in the sample collected at the 7-foot depth from DW-20. Generally, samples collected from DW-20 exhibited the highest number of detected VOCs and the highest concentrations compared with samples collected from other dry wells. Acetone, xylenes, and toluene were the most frequently detected VOCs (detected in 20, 11, and 8 samples, respectively).

Analytical results for volatile TICs from samples collected from Tacoma City Light dry wells are presented in Section 7.0 of the Data Appendix. The lowest detected concentration was 20 $\mu\text{g/kg}$ for 1,3-dichlorobenzene in the sample collected at the 13-foot depth from DW-20. The highest detected concentration was 25,000 $\mu\text{g/kg}$ for 1,4 dichlorobenzene in the sample collected at the 7-foot depth from DW-20.

PAH, semivolatile, and volatile organic compounds detected in Tacoma City Light dry wells could be the result of wood treatment operations. Wood treatment technologies generally employ three different types of compounds: creosote, pentachlorophenol in a heavy oil carrier, and metallic salts composed primarily of copper, chromium, and arsenic.

Creosote is generally composed of 35 percent aliphatic hydrocarbons and 65 percent PAHs. 2-Methylnaphthalene, dibenzofuran, and carbazole are also found in creosote. These compounds were found to be associated with elevated PAH concentrations at DW-13, DW-19, DW-22, and DW-26.

Pentachlorophenol (PCP) is used for wood preserving and applied as a component in a heavy carrier oil. Benzene, toluene, and total xylenes may also be components of the carrier oil. PCP was detected in DW-26. Benzene, toluene, and total xylenes were detected in some of the dry wells.

4.2.4.4 Pesticides/PCBs. Table SS-62 also presents a summary of the analytical results for pesticides and PCBs. Only one pesticide was detected in samples collected from the Tacoma City Light dry wells. Aldrin was detected in the four samples collected from DW-13; concentrations decreased with depth, ranging from 2,000 $\mu\text{g/kg}$ (7-foot depth) to 200 $\mu\text{g/kg}$ (13-foot depth). Figure SS-13 presents the change in concentration with depth for aldrin in DW-13.

PCBs were detected in 10 samples collected from five dry wells (DW-18, DW-19, DW-20, DW-21, and DW-26). Detected PCB concentrations ranged from 190 $\mu\text{g/kg}$ in the sample collected at the 13-foot depth from DW-19 to 840,000 $\mu\text{g/kg}$ in the sample collected at the 7-foot depth from DW-20.

PCB concentrations are the sum of all isomers detected. Three PCB isomers were detected: Aroclor 1248, Aroclor 1254, and Aroclor 1260. PCB concentrations generally decreased with depth, except in DW-20, where the PCB concentration increased from 270,000 $\mu\text{g/kg}$ at the 9-foot depth to 390,000 $\mu\text{g/kg}$ at the 11-foot depth. In three of the five wells in which PCBs were detected, samples were from the shallowest depths. In only two dry wells (DW-19 and DW-20), PCBs were detected in samples collected from the deepest sample depths, as well as from the more shallow locations.

4.2.5 Summary of Pioneer Builders Supply Subsurface Organic Analytical Results

4.2.5.1 PAHs. Table SS-63 presents a summary of the total probable carcinogenic PAH and total PAH analytical results. Complete analytical results are presented in Section 7.0 of the Data Appendix. PAHs were detected in 14 of the 27 samples collected at Pioneer Builders Supply. Probable carcinogenic PAHs were detected in only four of the samples collected and ranged in concentration from 0.012 mg/kg [benzo(k)fluoranthene at 18-foot depth in B-1] to 0.20 mg/kg [chrysene at 0.5-foot depth in B-1]. Total probable carcinogenic PAH concentrations ranged from

TABLE SS-63
SUMMARY OF ORGANIC ANALYTICAL RESULTS
FOR PIONEER BUILDER SUPPLY SUBSURFACE SOIL SAMPLES

Boring No. (Depth in feet)	PAHs(mg/kg) ^(a,b)		Semivolatile Organic Compounds (µg/kg) ^(a,b)									Volatile Organic Compounds (µg/kg) ^(a,b)					PCBs (µg/kg) ^(a,b,c)
	Total Probable Carcinogenic	Total PAHs	1,2,4-Tri-chlorobenzene	2-Methyl-naphthalene	Bis(2-ethylhexyl)-phthalate	Carbozole	Butylbenzyl-phthalate	Phenol	4-Chloro-aniline	Dibenzo-furan	Methylene Chloride	Acetone	Toluene	Ethylbenzene	Total Xylenes		
B-1																	
(0.5)	0.50	1.3	—	J 260	J 78	J 210	—	—	—	J 65	—	—	—	—	—	*	
(3.0)	0.041	0.28	—	—	J 44	—	—	—	—	—	—	—	20	—	—	*	
(8.0)	0.041	0.28	—	—	—	—	—	—	—	—	—	B 17 J	J 2 J3	—	—	*	
(13.0)	0.044	0.29	—	—	—	—	—	—	—	—	—	B 20 J	—	—	—	*	
(18.0)	0.095	0.78	J 130	—	—	—	—	—	—	—	—	—	240 J4	—	—	*	
(23.0)	0.044	22.1	10,000	1,900	—	—	—	—	—	—	—	—	—	—	—	—	
(28.0)	0.045	0.50	5,000	410	—	—	—	—	—	—	—	—	—	—	—	*	
B-2																	
(17.0)	0.044	0.31	930	J 220	—	—	—	—	—	—	—	—	—	—	—	11,000	
(22.0)	0.044	0.95	1,600	840	—	—	—	—	—	—	—	B 13 J4	—	—	—	*	
(27.0)	0.048	0.32	J 130	640	—	—	—	—	—	—	B 180 J4	B 36 J4	24	J 11	39	*	
(32.0)	0.048	0.32	J 58	J 80	J 160	—	—	—	—	—	—	—	—	—	—	—	
B-3																	
(18.5)	0.045	2.1	D 4,200	D 9,100	—	—	—	—	—	—	—	—	5,200 J	10,000 J	51,900 J	*	
(22.0)	0.045	0.30	D 980	D 3,800	—	—	—	—	—	—	—	JB 760 J	—	—	—	3,200	
(27.0)	0.045	1.4	—	J 200	J 63	—	—	—	—	—	—	—	—	—	—	1,000	
(32.0)	0.044	0.40	J 340	2,400	J 75	—	—	—	—	—	—	—	—	—	J 1,200 J3	*	
B-4																	
(0.5)	0.044	0.31	—	DJ 390	—	—	—	—	—	—	B 160 J3	—	41 J3	—	—	*	
(3.0)	0.044	0.29	J 50	J 53	J 50	J 100	J 64	—	—	—	—	—	—	—	—	*	
(8.0)	0.20	0.59	J 110	—	890	—	360	—	—	—	E 1,000 J4	—	71 J4	—	—	*	
(13.0)	0.044	0.29	—	—	J 76	—	—	—	—	—	—	—	—	—	—	*	
(18.0)	0.044	0.30	—	—	J 79	—	—	—	—	—	B 100 J3	B 130 J	86 J3	—	—	*	
(23.0)	0.044	0.30	—	—	—	—	—	—	—	—	—	B 21 J	67 J3	—	—	—	
(28.0)	0.054	1.9	—	1,600	—	—	—	—	—	—	—	—	J 550 J3	—	J 430 J3	*	
NMW-1A																	
(18.5)	0.044	0.30	J 120	J 34	—	—	—	—	—	—	—	—	—	—	—	*	
(22.5)	0.044	0.29	—	J 52	—	—	—	J 190	—	—	—	—	—	—	11	*	
(28.0)	0.048	0.40	J 110	860	1,600	—	—	—	J 130	—	—	—	—	—	J 510	*	
(33.5)	0.045	2.5	—	5,600	—	—	—	—	—	—	J 970	—	—	—	J 1,100 J4	—	
(38.5)	0.044	0.30	—	J 240	—	—	—	—	—	—	—	—	—	—	J 500	—	

- (a) Each analyte column has three subdivisions: 1) the left margin contains the laboratory qualifiers; 2) the middle value is the detected concentration; and 3) the right margin contains the data validation qualifiers.
- (b) Organic Data Qualifiers (also see Data Appendix):
 J3 - Estimated value. Holding times not met; indicates low bias for most analytes.
 J4 - Estimated value. Other QC outside control limits; bias not readily determined.
 D - Sample was diluted prior to analysis.
 — - Undetected value (see Data Appendix for detection limits and associated qualifiers).
- (c) * - Analysis not performed.

0.041 mg/kg to 0.5 mg/kg. Total PAH concentrations ranged from 0.28 mg/kg to 2.5 mg/kg.

In instances where PAH concentrations were detected in samples collected at two or more depths in a boring, concentrations usually decreased with increasing depth. In a few borings, however, total PAH concentrations increased over a short distance. For example, in boring B-1 total PAH concentrations increased from 0.78 mg/kg at 18-foot depth to 22.1 mg/kg at 23-foot depth. Generally, total probable carcinogenic PAH concentrations remained fairly consistent with depth in each boring.

The maximum total PAH concentration (22.1 mg/kg) was detected in the sample collected at the 23-foot depth from B-1. The maximum total probable carcinogenic concentration of 0.5 mg/kg was detected in the sample collected at 0.5 feet from boring B-1.

4.2.5.2 Semivolatile Organic Compounds. Table SS-63 also presents a summary of the semivolatile organic compounds analytical results. Eight semivolatile organic compounds (not including PAHs; see discussion in Section 4.1.2) were detected in samples collected from Pioneer Builders Supply, including 1,2,4-trichlorobenzene; 2-methylnaphthalene; bis(2-ethylhexyl) phthalate; carbazole; butylbenzylphthalate; phenol; 4-chloroaniline; and dibenzofuran. The first two compounds were the most frequently detected (50 percent or more of samples). Boring B-4 (located outside the excavation pit, see Figure SS-8) had the most detected analytes (12), but all other borings exhibited at least seven detected semivolatile organic compounds.

Phenol, 4-chloroaniline, and dibenzofuran were each detected in only one sample at concentrations of 190 $\mu\text{g/kg}$, 130 $\mu\text{g/kg}$, and 65 $\mu\text{g/kg}$, respectively. Carbazole and butylbenzylphthalate were each detected in only two samples at maximum concentrations of 210 $\mu\text{g/kg}$ and 360 $\mu\text{g/kg}$, respectively. Bis(2-ethylhexyl)-phthalate was detected in 10 samples at a concentration range of

44 $\mu\text{g/kg}$ -1,600 $\mu\text{g/kg}$. 1,2,4-Trichlorobenzene was detected in 14 samples at a concentration range of 50 $\mu\text{g/kg}$ -10,000 $\mu\text{g/kg}$. 2-Methylnaphthalene was detected in 19 samples at a concentration range of 34 $\mu\text{g/kg}$ -9,100 $\mu\text{g/kg}$.

In many boring locations, semivolatile organic compound concentrations increased with increasing depth, at least for one sampling interval. For example, in boring B-2, 1,2,4-trichlorobenzene increased in concentration from 930 $\mu\text{g/kg}$ at the 17-foot depth to 1,600 $\mu\text{g/kg}$ at the 22-foot depth. In fewer instances, concentrations declined with depth.

Analytical results for TICs from samples collected from Pioneer Builders Supply are presented in Section 7.0 of the Data Appendix. The lowest concentration (33 $\mu\text{g/kg}$) for 5-methyl-2-(1)cyclohexanone was detected in the sample collected at the 33.5-foot depth from NMW-1A. The highest concentration (14,000 $\mu\text{g/kg}$) for eicosane was detected in the sample collected at the 38.5-foot depth from NMW-1A.

4.2.5.3 Volatile Organic Compounds. Table SS-63 also presents a summary of the analytical results for VOCs. Complete analytical results are presented in Section 7.0 of the Data Appendix. Five VOCs were detected in the samples analyzed: methylene chloride, acetone, toluene, ethylbenzene, and total xylenes. Acetone and methylene chloride were also detected in most laboratory blanks; concentrations reported for soil samples collected from Pioneer Builders Supply are probably a result of laboratory contamination and not representative of actual soil concentrations.

Toluene was detected in 10 of the 27 samples collected at a concentration range of 2.0 $\mu\text{g/kg}$ -5,200 $\mu\text{g/kg}$. Ethylbenzene was detected in two samples at 11 $\mu\text{g/kg}$ and 10,000 $\mu\text{g/kg}$. Total xylenes were detected in eight samples at a concentration range of 11 $\mu\text{g/kg}$ -51,900 $\mu\text{g/kg}$. The most elevated concentrations of VOCs were detected in samples collected from boring B-3, which was located inside the excavation (see Figure SS-8).

VOCs (not including methylene chloride and acetone) that were detected in more than one sample collected from a particular boring did not exhibit a particular trend with regards to concentration vs depth. In three cases, concentrations increased with depth. In the other case, concentrations declined with depth.

Analytical results for volatile TICs from samples collected at Pioneer Builders Supply are presented in Section 7.0 of the Data Appendix. The lowest concentration (6.0 $\mu\text{g/kg}$) for 3,3-dimethyloctane was detected in the sample collected at the 18-foot depth from B-1. The highest concentration (50,000 $\mu\text{g/kg}$) for a cyclic hydrocarbon was detected in the sample collected at the 18.5-foot depth from NMW-1A.

4.2.5.4 Pesticides/PCBs. Table SS-63 also presents a summary of the analytical results for PCBs. Complete analytical results are available in Section 7.0 of the Data Appendix. Eight samples were analyzed for pesticides and PCBs. Pesticides were not detected in any samples. One PCB compound (Aroclor-1260) was detected in three of the samples from two borings (two samples from boring B-3 and one sample from boring B-2) at a concentration range of 1,000 $\mu\text{g/kg}$ -11,000 $\mu\text{g/kg}$. Borings B-2 and B-3 were located within the excavation area (see Figure SS-8).

4.3 SUPPLEMENTAL SOIL CHARACTERIZATION

4.3.1 Geotechnical Parameters

This section presents the results of the geotechnical testing performed on 40 surface soil samples collected from the STF site. Table SS-64 presents a summary of the tests results.

Moisture content was determined in the laboratory as outlined in ASTM D-2216 for 28 surface soil samples. Moisture content, which determines the amount of free liquid in a given amount of material, ranged from 2.1 percent (location 643) to

TABLE SS-64

**SUMMARY OF GEOTECHNICAL ANALYTICAL RESULTS
FOR SURFACE SOIL SAMPLES**

Location	Sampling Unit	Moisture Content (%)	Permeability (cm/sec)	Particle Size Distribution (%)			Soil Classification ^(a)	Bulk Density (pcf)	Field Dry Density (pcf)	Optimum Moisture Content (%)	Maximum Density (pcf)	Specific Gravity	Porosity (%)	Atterberg Limits		
				Gravel	Sand	Silt								Liquid	Plastic	Plasticity Index
325	BNR Dismantling Yard	9.2	1x10 ⁻⁴	60.2	35.0	4.8	GP	84.9	73.6 ^(b)	10.5	123.5	2.51	45.8	-- ^(c)	--	NP ^(d)
341	BNR Dismantling Yard	8.7	4x10 ⁻⁶	51.2	40.5	8.3	GW-GM	109.5	108.5	10.5	124.5	2.59	32.2	--	--	NP
485	BNR Dismantling Yard	8.6	4x10 ⁻⁵	48.5	44.3	7.2	GP-GM	98.8	107.9 ^(b)	13.6	114.4	2.54	38.9	--	--	NP
255	BNR Dismantling Yard	NA ^(e)	NA	29.8	57.4	12.8	SM	NA	NA	NA	NA	NA	NA	NA	NA	NA
448	BNR Dismantling Yard	NA	NA	63.8	31.6	4.6	GW	NA	NA	NA	NA	NA	NA	NA	NA	NA
549	BNR Dismantling Yard	NA	NA	26.1	58.2	15.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composite	BNR Dismantling Yard	7.7	NA	48.2	48.2	3.6	GP	NA	NA	15.5	109.5	2.51	NA	32	32	NP
747	Former Swamp/Lakebed	7.9	3x10 ⁻⁶	34.2	48.0	17.8	SM	116.2	118.5	9.0	130.5	2.75	33.0	--	--	NP
770	Former Swamp/Lakebed	4.6	1x10 ⁻⁴	31.3	64.7	4.0	SP	115.1	125.7 ^(b)	10.0	125.5	2.68	31.2	--	--	NP
821	Former Swamp/Lakebed	5.8	2x10 ⁻⁶	49.3	37.9	12.8	GM	129.9	129.9	5.8	140.5	2.64	21.1	--	--	NP
804	Former Swamp/Lakebed	NA	NA	58.0	33.3	8.7	GP-GM	NA	NA	NA	NA	NA	NA	NA	NA	NA
880	Former Swamp/Lakebed	NA	NA	35.7	54.6	9.7	SP-SM	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composite	Former Swamp/Lakebed	6.5	NA	20.5	67.3	12.2	SM	NA	NA	7.0	136.5	2.72	NA	--	--	NP
599	Airport	9.5	1x10 ⁻⁴	38.8	49.0	12.2	SM	91.0	87.6	11.0	122.5	2.50	41.7	--	--	NP
611	Airport	4.7	4x10 ⁻⁵	51.3	42.5	6.2	GP-GM	116.1	132.7 ^(b)	8.0	133.0	2.65	29.8	--	--	NP
643	Airport	2.1	7x10 ⁻⁵	61.9	35.3	2.8	GP	115.4	119.4	9.8	125.8	2.57	28.1	--	--	NP
667	Airport	4.4	3x10 ⁻⁵	59.5	35.4	5.1	GP-GM	108.8	115.7 ^(b)	9.6	127.8	2.59	32.7	--	--	NP
555	Airport	NA	NA	41.5	48.4	10.1	SM-SP	NA	NA	NA	NA	NA	NA	NA	NA	NA
697	Airport	NA	NA	58.4	37.8	3.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composite	Airport	4.1	NA	56.5	38.8	4.7	GP	NA	NA	8.6	130.6	2.59	NA	30	32	NP
799	Amsted	16.1	6x10 ⁻⁵	1.9	79.8	18.3	SM	84.5	82.1	16.8	100.0	2.48	45.4	--	--	NP
847	Amsted	6.5	4x10 ⁻⁴	48.7	45.3	6.0	GM-GP	114.9	114.1	13.5	128.0	2.89	36.3	--	--	NP
819	Amsted	NA	NA	2.7	65.1	32.2	SM	NA	NA	NA	NA	NA	NA	NA	NA	NA
829	Amsted	NA	NA	19.8	65.0	15.2	SM	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composite	Amsted	11.7	NA	16.0	73.9	10.1	SM-SW	NA	NA	15.0	118.0	2.65	NA	--	--	NP

TABLE SS-64

**SUMMARY OF GEOTECHNICAL ANALYTICAL RESULTS
FOR SURFACE SOIL SAMPLES**

Location	Sampling Unit	Moisture Content (%)	Permeability (cm/sec)	Particle Size Distribution (%)			Soil Classification ^(a)	Bulk Density (pcf)	Field Dry Density (pcf)	Optimum Moisture Content (%)	Maximum Density (pcf)	Specific Gravity	Porosity (%)	Atterberg Limits		
				Gravel	Sand	Silt								Liquid	Plastic	Plasticity Index
586	BNR Railyard	4.4	4x10 ⁻⁵	3.9	87.9	8.2	SP-SM	105.1	106.9	11.6	110.5	2.62	35.7	--	--	NP
703	BNR Railyard	20.8	2x10 ⁻⁵	38.7	45.2	16.1	SM	83.7	87.7	15.0	89.0	2.34	39.1	--	--	NP
780	BNR Railyard	5.8	5x10 ⁻⁵	55.6	37.9	6.5	GM-GP	115.3	117.2	8.0	128.0	2.52	26.7	--	--	NP
895	BNR Railyard	17.5	3x10 ⁻⁴	40.3	50.6	9.1	SM-SW	76.8	90.3 ^(b)	27.0	80.0	2.12	38.0	--	--	NP
740	BNR Railyard	NA	NA	43.6	46.9	9.5	SP-SM	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composite	BNR Railyard	11.5	NA	28.7	64.4	6.9	SM-SP	NA	NA	13.0	108.8	2.48	NA	--	--	NP
716	TIP	8.3	5x10 ⁻⁴	41.1	49.8	9.1	SP-SM	64.9	62.0 ^(e)	8.5	109.5	2.54	30.9	--	--	NP
726	TIP	5.0	2x10 ⁻⁴	27.8	49.8	22.4	SP	106.0	106.5	10.0	126.0	2.61	34.9	--	--	NP
727	TIP	NA	NA	55.0	41.8	3.2	GP	NA	NA	NA	NA	NA	NA	NA	NA	NA
745	TIP	NA	NA	38.5	55.6	5.9	SW-SM	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composite	TIP	7.0	NA	37.5	51.5	11.0	SM-SP	NA	NA	12.0	117.5	2.43	NA	--	--	NP
668	Surface Water Channel	24.3	3x10 ⁻⁵	46.4	47.2	6.4	SP-SM	84.2	107.7 ^(b,f)	30.5	89.5	2.50	46.0	--	--	NP
766	Surface Water Channel	22.3	5x10 ⁻⁴	19.2	50.0	30.8	SM	101.7	101.6	9.0	133.8	2.75	40.2	--	--	NP
878	Surface Water Channel	4.4	1x10 ⁻⁶	55.0	39.0	16.0	GM	133.0	136.6	6.0	137.0	2.68	20.4	--	--	NP
2516	Surface Water Channel	27.3	1x10 ⁻⁶	20.1	65.5	14.4	SM	102.0	62.6 ^(b,f)	13.0	114.0	2.53	35.4	--	--	NP

(a) GP/GW = Poorly/well-graded gravels and gravel-sand mixtures, little or no fines.

GM = Silty gravels, gravel-sand-silt mixtures.

SP/SW = Poorly/well-graded sands and gravelly sands, little or no fines.

SM = Silty sands, sand-silt mixtures.

(b) Sample recompact to 50 percent relative density because field tests were not representative of the laboratory sample.

(c) -- = Not meaningful.

(d) NP = Non-plastic.

(e) NA = Not analyzed/calculated.

(f) Sample location below water; field dry density reading taken as close as possible to original sample location.

27.3 percent (location 2516). The area adjacent to the surface water channel exhibited the highest moisture content compared to other sampling units at the STF site. The BNR Railyard also exhibited soil with high moisture content, while samples collected from the Airport showed relatively low moisture content.

The permeability of 22 surface soil samples was measured in the laboratory as described in ASTM D-5084. Because of the general non-cohesive nature of the soil, representative samples could not be collected without disturbance. Consequently, in-situ density (ASTM D-2922) and in-situ water content (ASTM D-3017) data were used to recompact the laboratory samples to the same density and moisture content as determined in the in-situ test prior to performing the permeability tests.

The target unit weight of the recompacted samples was intended to be the dry density as determined by the in-situ tests. However, because some of the field test data were not representative of the corresponding laboratory samples (Table SS-64), the laboratory sample was compacted to a density which was approximately 50 percent relative density. Fifty percent relative density was selected as an average value to minimize resulting errors in the permeability tests.

Permeability coefficients of the soil ranged from 1×10^{-6} centimeters per second (cm/sec) (locations 878 and 2516) to 5×10^{-4} cm/sec (locations 716 and 766). Soil is considered impervious when the permeability coefficient is less than 1×10^{-6} cm/sec and pervious if the permeability coefficient is greater than 1×10^{-4} cm/sec (Lindeburg 1986). Some soil from Amsted, the BNR Railyard, TIP, and the surface water channel exhibited pervious characteristics. Soil samples from the surface water channel also exhibited the most impervious characteristics when compared to results for other onsite soil samples. However, no soil sample exceeded the 1×10^{-6} cm/sec criteria for imperviousness. Of the 22 samples analyzed for permeability, 17 can be classified as being between the pervious and impervious criteria.

Particle size analyses were performed in accordance with ASTM D-1140 and ASTM C-136 on 40 surface soil samples. Sieve analysis results are summarized in Table SS-64. The test methods do not differentiate between silts and clays. Because most samples are non-plastic (see Atterberg Limits section) all fine material (particles passing the #200 sieve) are categorized as silts.

Soils were classified in accordance with the Unified Soil Classification System (ASTM D-2487). Soil samples were classified as poorly- or well-graded sands and gravel; silty sands; silty gravel; and combinations of these classifications (e.g. well-graded gravels and silty gravels). These soil classifications would be expected based on the Soil Conservation Service soil survey (USDA 1979) of areas in proximity to the STF site (see Section 1.3.2 in this report).

Bulk density is the weight of the soil divided by the total volume of the sample, and is often used in materials handling calculations to determine the rate at which soil can be excavated. Bulk densities, calculated in accordance with ASTM D-2937, ranged from 64.9 pounds/cubic foot (pcf) (location 716) to 133.0 pcf (location 878).

Compaction tests were performed in accordance with ASTM D-1557 on 28 surface soil samples to provide information on the density and the corresponding moisture content. The maximum dry densities ranged from 80.0 pcf (location 703) to 140.5 pcf (location 821). The maximum dry densities correspond approximately to the typical values expected for the soil classifications encountered at the STF site, except for some of the silty sands from the BNR Railyard and area adjacent to the surface water channel which have lower maximum dry densities than might usually be expected (Lindeburg 1986).

Specific gravity was determined for 20 surface soil samples in accordance with ASTM D-854. Porosity, a measure of the void space in a volume of soil, was then calculated using the dry density and specific gravity values. Specific gravity ranged from 2.12 (location 895) to 2.89 (location 847). Porosity ranged from 20.4 percent (location 878) to 46.0 percent (location 668).

Atterberg limits describe the water content corresponding to the transition of a soil from the solid to plastic state or plastic to liquid state. These transitions are known as the plastic limit and liquid limit, respectively. The plasticity index is the difference between the liquid and plastic limits. The plastic limit is dependent on the clay content of the soil. Soil without plastic limits is classified as non-plastic. The 28 samples analyzed by the Atterberg test (ASTM D-4318) showed all soil to be non-plastic.

4.3.2 Total Organic Carbon (TOC)

Total organic carbon (TOC) was determined using EPA Method 9060. Table SS-65 presents the TOC analytical results. TOC concentrations ranged from 2,120 mg/kg (location 878) to 420,000 mg/kg (location 847). In general, TOC concentrations were higher in Amsted and the BNR Railyard. The majority of organic material in the soil is probably a combination of nonpolar organic components (e.g., oil and grease and aromatic hydrocarbons) and plant material.

4.4 FIELD OBSERVATIONS

Field observations were recorded in a bound notebook during sample collection. The following observations were noted:

- Sampling location description
- Description of visual contamination (if any)
- Depth
- Organic vapor analyzer (or meter) reading
- Soil color, moisture, and odor
- Laboratory analyses requested
- Comments.

TABLE SS-65

**TOTAL ORGANIC CARBON ANALYTICAL RESULTS
FOR SURFACE SOIL SAMPLES**

Location No.	Sampling Unit	Total Organic Carbon (mg/kg)
325	BNR Dismantling Yard	48,100
341	BNR Dismantling Yard	25,600
485	BNR Dismantling Yard	26,500
990	BNR Dismantling Yard	26,600
747	Former Swamp/Lakebed	10,400
770	Former Swamp/Lakebed	5,100
821	Former Swamp/Lakebed	7,640
991	Former Swamp/Lakebed	3,400
599	Airport	64,800
611	Airport	11,800
643	Airport	11,000
667	Airport	32,500
992	Airport	15,200
799	Amsted	40,500
847	Amsted	420,000
993	Amsted	34,600
586	BNR Railyard	17,300
703	BNR Railyard	246,000
780	BNR Railyard	35,500
895	BNR Railyard	69,500
994	BNR Railyard	30,800
716	TIP	62,100
726	TIP	30,200
995	TIP	29,300
668	Surface Water Channel	47,100
766	Surface Water Channel	13,200
878	Surface Water Channel	2,120
2516	Surface Water Channel	17,800

Field observations in the Phase I Soil Investigation database includes yes/no data fields for visual contamination, odor, OVA reading, and comments. Complete fieldnotes are stored in the STF Project Files in the office of Kennedy/Jenks Consultants, Federal Way, Washington.

5.0 SUMMARY AND CONCLUSIONS

Conclusions for the Phase I Soil Investigation are presented for the surface soil investigation and for the preliminary subsurface investigations at Tacoma City Light and Pioneer Builders Supply.

5.1 SURFACE SOIL

- Inorganics were detected at concentrations elevated above background (i.e., offsite) concentrations in surface soil at various locations within the STF site. Generally, Amsted, the BNR Railyard, and the BNR Dismantling Yard exhibited the most elevated concentrations of inorganics. The industrial activities that occurred at some locations at the site, including filling operations, probably contributed to the elevated inorganic concentrations.
- PAH compounds were detected at concentrations above background concentrations in surface soil throughout the STF site. The detection of PAH compounds may be attributed to the incomplete combustion of fossil fuels and possibly from the use of treated wood onsite.
- Generally, samples collected from the Airport showed the lowest concentrations of organics.
- Semivolatile organic compounds were detected at relatively low concentrations (i.e., less than 10 $\mu\text{g/kg}$) primarily in samples collected from the BNR Dismantling Yard and BNR Railyard. Because only 20 percent of all samples were analyzed for semivolatile organic compounds, it was not possible to identify distribution trends for these compounds.

- Methylene chloride, acetone, toluene were the VOCs most frequently detected (i.e., greater than 5 percent of analyses) in samples collected from the site. Of these VOCs, methylene chloride and acetone were frequently detected in laboratory blanks, and their detection in samples collected from the site is apparently attributable to laboratory contamination. Toluene was detected in just over half of the samples collected from the site, but only four samples (all from the BNR Railyard) exhibited concentrations exceeding 100 $\mu\text{g}/\text{kg}$. Trace concentrations (i.e., less than 100 $\mu\text{g}/\text{kg}$) of several other VOCs were detected in samples collected from the BNR Railyard and Dismantling Yard. Each of these other VOCs was detected in less than 5 percent of the samples collected. Because only 20 percent of all samples were analyzed for VOCs, it was not possible to identify distribution trends for these compounds.
- Except for one sample (collected from the BNR Railyard) that contained 390 $\mu\text{g}/\text{kg}$ of methoxychlor, pesticides were detected in only a few samples at low (i.e., < 100 $\mu\text{g}/\text{kg}$) concentrations collected from scattered locations throughout the site.
- Except for elevated concentrations detected in three samples from the BNR Railyard, PCBs were detected at low concentrations (< 1 $\mu\text{g}/\text{kg}$) in samples collected from the BNR Dismantling Yard and BNR Railyard. PCBs were detected primarily in samples collected from areas near the existing railroad line, from a location in the southeastern section of the BNR Dismantling Yard, and from an adjacent area in the northern end of the BNR Railyard. Further investigation is warranted in the southeastern area of the BNR Dismantling Yard, and locations in the northern end of the BNR Railyard. (Further investigations will be proposed in conjunction with the Phase II Soil Investigation.)
- Dioxins and furans were not detected above concentrations that would be expected in samples collected from an industrialized area.

- Geotechnical testing results indicated that the surface soil is generally characteristic of sandy soils mixed with gravel.

5.2 TACOMA CITY LIGHT

- Concentrations of inorganics detected in Tacoma City Light dry wells were generally less than 1 order of magnitude greater than background concentrations. In no case were the elevated concentrations greater than 2 orders of magnitude compared to background concentrations.
- Subsurface maximum inorganic concentrations were significantly less (frequently by 1-2 orders of magnitude) compared to the maximum concentrations for surface soil samples collected in other sampling units at STF.
- The vertical concentration distributions of inorganics in the dry wells were not uniform. That is, concentrations would often decrease then increase (or vice versa) over a relatively short vertical sampling interval. This variability may be caused by changes in soil absorption characteristics, change in hydraulic characteristics, or other factors.
- Detected concentrations of PAHs and some of the semivolatiles and VOCs may have resulted from the incomplete combustion of fossil fuels and leaching of wood treatment constituents from treated telephone and utility poles. Concentrations of these chemicals typically decreased with increased vertical sampling depth.
- PCBs may have originated from historical handling and storage of transformers containing PCB-bearing dielectric fluids (Askarel). Spillage may have occurred during maintenance of these transformers or during replacement of the Askarel with non-PCB dielectric fluids. Where detected,

PCB concentrations declined at least 1 order of magnitude over the intervals sampled.

- The pesticide aldrin (detected in DW-13) may have been the result of spillage of a pesticide/herbicide mixture. Other compounds detected at the site were also historically used as or in pesticides. These chemicals include chlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, and diethylphthalate.
- Sources of VOC compounds detected in dry well soil could have been from solvents used in maintenance activities for utility equipment. Semivolatile organic compounds detected at Tacoma City Light may have been contained in plastic materials used by the utility. Other sources of semivolatile organic compounds at the Tacoma City Light property were not identified.

5.3 PIONEER BUILDERS SUPPLY

- Most chemicals of concern detected in subsurface soil samples collected from Pioneer Builders Supply were present at low concentrations and with limited vertical and horizontal distributions.
- Detected concentrations of inorganics were generally consistent with or lower than surface soil background concentrations (95% UCL).
- Low to moderate concentrations (i.e., up to 52 $\mu\text{g}/\text{kg}$) of VOCs (i.e., toluene, ethylbenzene, and total xylenes) were detected in the native soil at the base of the former tank removal excavation and in samples collected from borings outside the excavation. The underground storage tanks (USTs) formerly in this area likely contained petroleum products. The

former USTs were probably the source of these VOCs as well as the hydrocarbon TICs identified during the VOC and semivolatile analyses.

- Only three semivolatile organic compounds were detected in more than two samples collected from Pioneer Builders Supply. The highest concentrations were detected in B-1 and B-3, which were advanced in soil directly underlying the former USTs. The source of these compounds may also be from releases of hazardous substances from the former USTs.
- PAH compounds were detected in half of the samples collected from Pioneer Builders Supply. Concentrations of total PAHs did not exceed 2.5 mg/kg (except in one instance from boring B-1 at the 23-foot depth) and the sum of carcinogenic PAHs detected did not exceed 0.5 mg/kg in any sample.
- PCBs were detected at concentrations equal to or less than 11 mg/kg in three samples collected from the excavation area. PCBs were also identified at moderate concentrations as semivolatile TICs in samples collected from B-1 and B-2. The source of these PCBs is unknown.

Specific recommendations for further subsurface investigation at the STF site will be presented in the Phase II Subsurface Soil Sampling and Analysis Plan Amendment.

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Appendix SS-A

Boring Logs

**Tacoma City Light
Boring Logs**

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION TACOMA CITY LIGHT				Boring/Well Name DW-10			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		DRILLER GLEN		Project Name STF PH 1 SOIL-DRYWELLS			
DRILLING METHOD HOLLOW STEM AUGER		DRILL BIT(S) SIZE: 6 5/8" O.D.		Project Number 916055.06			
ISOLATION CASING N/A		FROM TO FT.		ELEVATION AND DATUM		TOTAL DEPTH 16.5	
BLANK CASING N/A		FROM TO FT.		DATE STARTED 05/07/1991		DATE COMPLETED 05/07/1991	
PERFORATED CASING N/A		FROM TO FT.		INITIAL WATER DEPTH (FT)			
SIZE AND TYPE OF FILTER PACK N/A		FROM TO FT.		LOGGED BY T. C. MORIN			
SEAL BENTONITE CHIPS		FROM 2.5 TO 16.5 FT.		SAMPLING METHODS 2.5" SPLIT SPOON		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.	
GROUT N/A		FROM TO FT.					

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)						
								DRY WELL - OPEN HOLE
G	1.0		5			CH		FAT CLAY: white, moist, soft (BENTONITE SEAL MATERIAL)
U	2.0	4 6 9 10	10	DW-10-9.0				POORLY-GRADED SAND: grey, moist, dense; mostly medium to fine sand, strong hydrocarbon odor
U	1.4	18 40 50		DW-10-11.0		SP		
U	1.8	15 26 36 38	15	DW-10-13.0 (A)				90% fine sand
U	1.4	32 46 59		DW-10-15.0				

Notes:

(A) K/J duplicate #1716 collected

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION TACOMA CITY LIGHT				Boring/Well Name DW-13			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES			DRILLER GLEN			Project Name STF PH 1 SOIL-DRYWELLS	
DRILLING METHOD HOLLOW STEM AUGER			DRILL BIT(S) SIZE: 6 5/8" O.D.			Project Number 916055.06	
ISOLATION CASING N.A.		FROM		TO		FT.	
BLANK CASING N.A.		FROM		TO		FT.	
PERFORATED CASING N.A.		FROM		TO		FT.	
SIZE AND TYPE OF FILTER PACK N.A.		FROM		TO		FT.	
SEAL BENTONITE CHIPS		FROM 2.0		TO 14.5		FT.	
GROUT N.A.		FROM		TO		FT.	
ELEVATION AND DATUM				TOTAL DEPTH 14.5			
DATE STARTED 05/07/1991				DATE COMPLETED 05/07/1991			
INITIAL WATER DEPTH (FT)							
LOGGED BY T. C. MORIN							
SAMPLING METHODS 2.5" SPLIT SPOON				WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.			

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)						
								DRY WELL - OPEN HOLE
G	1.0							
			5					
U	1.0	0		DW-13-6.0				
U	1.8	6 16 27 38		DW-13-7.0				
U	1.7	4 17 28 31	10	DW-13-9.0				
U	1.3	21 31 56		DW-13-11.0				
U	1.4	33 66 80		DW-13-13.0				

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION TACOMA CITY LIGHT		Boring/Well Name DW-15	
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES	DRILLER GLEN	Project Name STF PH 1 SOIL-DRYWELLS	
DRILLING METHOD HOLLOW STEM AUGER	DRILL BIT(S) SIZE: 6 5/8" O.D.	Project Number 916055.06	
ISOLATION CASING N.A.	FROM TO FT.	ELEVATION AND DATUM	TOTAL DEPTH 17.0
BLANK CASING N.A.	FROM TO FT.	DATE STARTED 05/07/1991	DATE COMPLETED 05/07/1991
PERFORATED CASING N.A.	FROM TO FT.	INITIAL WATER DEPTH (FT)	
SIZE AND TYPE OF FILTER PACK N.A.	FROM TO FT.	LOGGED BY T. C. MORIN	
SEAL BENTONITE CHIPS	FROM 5.0 TO 17.0 FT.	SAMPLING METHODS 2.5" SPLIT SPOON	WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.
GROUT N.A.	FROM TO FT.		

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/8 IN.)						
								DRY WELL - OPEN HOLE
G	1.0		5					
U	1.4	30 32 50	10	DW-15-9.0				
U	1.3	16 21 40		DW-15-11.0				
U	1.9	35 25 20 36	15	DW-15-13.0 (A)				
U	1.8	21 25 29 33		DW-15-15.0 (B)				

Notes:

(A) K/J duplicate #1715 collected

(B) ICF duplicate collected

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION TACOMA CITY LIGHT				Boring/Well Name DW-18			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES			DRILLER GLEN			Project Name STF PH 1 SOIL-DRYWELLS	
DRILLING METHOD HOLLOW STEM AUGER			DRILL BIT(S) SIZE 6 5/8" O.D.			Project Number 916055.06	
ISOLATION CASING N/A		FROM		TO		FT.	
BLANK CASING N/A		FROM		TO		FT.	
PERFORATED CASING N/A		FROM		TO		FT.	
SIZE AND TYPE OF FILTER PACK N/A		FROM		TO		FT.	
SEAL BENTONITE CHIPS		FROM 2.0		TO 17.0		FT.	
GROUT N/A		FROM		TO		FT.	
ELEVATION AND DATUM				TOTAL DEPTH 17.0			
DATE STARTED 05/06/1991				DATE COMPLETED 05/06/1991			
INITIAL WATER DEPTH (FT)							
LOGGED BY T. C. MORIN							
SAMPLING METHODS 2.5" SPLIT SPOON				WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.			

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLows/6 IN.)						
								DRY WELL - OPEN HOLE
G	1.0							FAT CLAY; white, moist, soft; (BENTONITE SEAL MATERIAL) oily discoloration in upper section, strong hydrocarbon odor
			5				CH	
U	2.0	0 1 1						
U	1.9	4 4 12 16	10	DW-18-9.0				POORLY-GRADED SAND; reddish brown, damp, dense; mostly medium sand, strong hydrocarbon odor
U	1.9	10 21 22 23		DW-18-11.0			SP	
U	1.8	15 25 23 30		DW-18-13.0				grey
U	1.7	19 29 23 45	15	DW-18-15.0				as above with ~15% medium gravel

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION TACOMA CITY LIGHT		Boring/Well Name DW-19	
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES	DRILLER GLEN	Project Name STF PH 1 SOIL-DRYWELLS	
DRILLING METHOD HOLLOW STEM AUGER	DRILL BIT(S) SIZE: 6 5/8" O.D.	Project Number 916055.06	
ISOLATION CASING N/A	FROM TO FT.	ELEVATION AND DATUM	TOTAL DEPTH 14.5
BLANK CASING N/A	FROM TO FT.	DATE STARTED 05/07/1991	DATE COMPLETED 05/07/1991
PERFORATED CASING N/A	FROM TO FT.	INITIAL WATER DEPTH (FT)	
SIZE AND TYPE OF FILTER PACK N/A	FROM TO FT.	LOGGED BY T. C. MORIN	
SEAL BENTONITE CHIPS	FROM 3.0 TO 14.5 FT.	SAMPLING METHODS 2.5" SPLIT SPOON	WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.
GROUT N/A	FROM TO FT.		

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/8 IN.)						
								DRY WELL - OPEN HOLE
G	1.0		5				CH	FAT CLAY white, moist, soft (BENTONITE SEAL MATERIAL); some black discoloration near surface, slight odor
U	2.0	8 10 14 21		DW-19-7.0				
U	1.9	13 15 19 21	10	DW-19-9.0 (A)			SP	POORLY-GRADED SAND; reddish brown, moist, dense; mostly medium sand, trace gravel, strong odor
U	0.9	31 66/5		DW-19-11.0				as above with ~10% coarse gravels
U	1.3	14 20 50		DW-19-13.0				

Notes:

(A) ICF duplicate sample collected

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION TACOMA CITY LIGHT				Boring/Well Name DW-20			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		DRILLER GLEN		Project Name STF PH 1 SOIL-DRYWELLS			
DRILLING METHOD HOLLOW STEM AUGER		DRILL BIT(S) SIZE: 6 5/8" O.D.		Project Number 916055.06			
ISOLATION CASING N/A		FROM TO FT.		ELEVATION AND DATUM		TOTAL DEPTH 15.0	
BLANK CASING N/A		FROM TO FT.		DATE STARTED 05/06/1991		DATE COMPLETED 05/06/1991	
PERFORATED CASING N/A		FROM TO FT.		INITIAL WATER DEPTH (FT)			
SIZE AND TYPE OF FILTER PACK N/A		FROM TO FT.		LOGGED BY T. C. MORIN			
SEAL BENTONITE CHIPS		FROM 4.0 TO 15.0 FT.		SAMPLING METHODS 2.5" SPLIT SPOON		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.	
GROUT N/A		FROM TO FT.					

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)						
								DRY WELL - OPEN HOLE
G	1.0		5					
U	1.0	0						
U	1.8	4 9 18		DW-20-7.0			CH	FAT CLAY; white, moist, soft (BENTONITE SEAL MATERIAL)
U	1.9	5 26 35 50	10	DW-20-9.0			SP	POORLY-GRADED SAND; reddish brown, moist, dense; mostly coarse sand, black discoloration in upper section, strong hydrocarbon odor, sheen on soil and free water odor decreases
U	1.7	8 11 19 31		DW-20-11.0				
U	1.8	21 29 31 34		DW-20-13.0				
			15					

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION TACOMA CITY LIGHT		Boring/Well Name DW-22	
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		Project Name STF PH 1 SOIL-DRYWELLS	
DRILLING METHOD HOLLOW STEM AUGER		Project Number 916055.06	
ISOLATION CASING N/A		ELEVATION AND DATUM	
FROM TO FT.		TOTAL DEPTH 15.0	
BLANK CASING N/A		DATE STARTED 05/06/1991	
FROM TO FT.		DATE COMPLETED 05/06/1991	
PERFORATED CASING N/A		INITIAL WATER DEPTH (FT)	
FROM TO FT.		LOGGED BY T. C. MORIN	
SIZE AND TYPE OF FILTER PACK N/A		SAMPLING METHODS 2.5" SPLIT SPOON	
SEAL BENTONITE CHIPS		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.	
GROUT N/A		FROM 4.0 TO 15.0 FT.	

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLDG/8 IN.)						
								DRY WELL - OPEN HOLE
U	2.0	2 1 2 1	5					
U	2.0	1 4 8		DW-22-7.0			CH	FAT CLAY; white, moist, soft (BENTONITE SEAL MATERIAL)
U	1.9	17 25 31 38	10	DW-22-9.0				POORLY-GRADED SAND; greyish red, moist, dense; mostly coarse to medium sand, strong hydrocarbon odor, soil becomes saturated, sheen on free water
U		21 38 47 57		DW-22-11.0			SP	
U	1.5	27 40 50	15	DW-22-13.5				grey, odor decreases

Boring & Well Construction Log

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BORING LOCATION TACOMA CITY LIGHT				Boring/Well Name DW-26			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		DRILLER GLEN		Project Name STF PH 1 SOIL-DRYWELLS			
DRILLING METHOD HOLLOW STEM AUGER		DRILL BIT(S) SIZE: 6 5/8" O.D.		Project Number 916055.06			
ISOLATION CASING N/A		FROM TO FT.		ELEVATION AND DATUM		TOTAL DEPTH 17.0	
BLANK CASING N/A		FROM TO FT.		DATE STARTED 05/08/1991		DATE COMPLETED 05/08/1991	
PERFORATED CASING N/A		FROM TO FT.		INITIAL WATER DEPTH (FT)			
SIZE AND TYPE OF FILTER PACK N/A		FROM TO FT.		LOGGED BY T. C. MORIN			
SEAL BENTONITE CHIPS		FROM 7.0 TO 17.0 FT.		SAMPLING METHODS 2.5" SPLIT SPOON		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.	
GROUT N/A		FROM TO FT.					

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/8 IN.)						
			5					DRY WELL - OPEN HOLE SILT; black, wet, very soft; strong odor and sheen, possible discoloration, abundant organic debris (wood, grass, leaves, etc.) POORLY-GRADED SAND; grey, moist, dense to very dense; mostly coarse sand, strong hydrocarbon odor
U	1.9	0	10	DW-26-9.0				
U	1.7	14 15 17 21		DW-26-11.0				
U	1.7	13 16 19 23		DW-26-13.0				
U	1.9	42 38 32 26	15	DW-26-15.0				

**Pioneer Builders Supply
Boring Logs**

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION PIONEER BUILDERS SUPPLY		Boring/Well Name B-1	
DRILLING COMPANY LAYNE ENVIRONMENTAL		Project Name STF PH 1 SOIL-PIONEER	
DRILLING METHOD HOLLOW STEM AUGER		Project Number 916055.07	
ISOLATION CASING N.A.		ELEVATION AND DATUM	
BLANK CASING N.A.		TOTAL DEPTH 30.0	
PERFORATED CASING N.A.		DATE STARTED 05/14/1991	
SIZE AND TYPE OF FILTER PACK N.A.		DATE COMPLETED 05/14/1991	
SEAL BENTONITE CHIPS		INITIAL WATER DEPTH (FT)	
GROUT CONCRETE		LOGGED BY T.C. MORIN	
		SAMPLING METHODS 2.5" SPLIT SPOON	
		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.	

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLows/8 IN.)						
U	0.2	2 5 10		B-1-0.5			SP	POORLY GRADED SAND WITH GRAVEL; blackish brown, damp, loose; mostly medium to coarse gravel, fine to medium gravel, some inert debris (brick frag. wood, nails); possible fill material
U	1.6	5 8 12	5	B-1-3.0				
U	1.8	35 20 28 23	10	B-1-8.0			GP	POORLY GRADED GRAVEL; greenish grey, moist, dense; 60% medium gravel, 40% sand, trace silt; slight hydrocarbon odor; silt fraction increases at 12', sand coarsens. gravel to 2" at 12'. 70% medium gravel at 18'
U	1.0	4 8 12 16	15	B-1-13.0				POORLY GRADED SAND; greyish brown, moist, very dense; 85% medium sand, 10% coarse gravel, trace silt; strong hydrocarbon odor at 25'
U	1.1	17 8 9 18	20	B-1-18.0				
U	1.6	50 49 32 56	25	B-1-23.0			SP	
U	1.7	72 52 43 48	30	B-1-28.0				

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION PIONEER BUILDERS SUPPLY				Boring/Well Name B-2			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		DRILLER GLENN BOUGE		Project Name STF PH 1 SOIL-PIONEER			
DRILLING METHOD HOLLOW STEM AUGER		DRILL BIT(S) SIZE: 6 5/8" I.D.		Project Number 916055.07			
ISOLATION CASING N.A.		FROM TO FT.		ELEVATION AND DATUM		TOTAL DEPTH 33.0	
BLANK CASING N.A.		FROM TO FT.		DATE STARTED 05/13/1991		DATE COMPLETED 05/13/1991	
PERFORATED CASING N.A.		FROM TO FT.		INITIAL WATER DEPTH (FT)			
SIZE AND TYPE OF FILTER PACK N.A.		FROM TO FT.		LOGGED BY T.C. MORIN			
SEAL BENTONITE CHIPS		FROM 2.0 TO 33.0 FT.		SAMPLING METHODS 2.5" SPLIT SPOON		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.	
GROUT CONCRETE		FROM 0.0 TO 2.0 FT.					

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/6 IN.)						
			5					WELL-GRADED SAND WITH SILT AND GRAVEL; mostly medium sand, 15% gravel, 15% silt; tank excavation backfill material
			10					
			15					
			20					
U	1.6	50 40 32 28		B-2-17.0				POORLY GRADED SAND; greenish gray, moist, dense; 85% medium sand, trace coarse gravel and silt; slight hydrocarbon odor sand fraction fines (~50% fine sand)
			25					
U	1.4	46 50 52		B-2-22.0				
			30					
U	1.4	42 50 56		B-2-29.0				

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION PIONEER BUILDERS SUPPLY				Boring/Well Name B-3			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		DRILLER GLENN BOUGE		Project Name STF PH 1 SOIL-PIONEER			
DRILLING METHOD HOLLOW STEM AUGER		DRILL BIT(S) SIZE: 6 5/8" I.D.		Project Number 916055.07			
ISOLATION CASING N.A.		FROM TO FT.		ELEVATION AND DATUM		TOTAL DEPTH 33.5	
BLANK CASING N.A.		FROM TO FT.		DATE STARTED 05/13/1991		DATE COMPLETED 05/13/1991	
PERFORATED CASING N.A.		FROM TO FT.		INITIAL WATER DEPTH (FT)			
SIZE AND TYPE OF FILTER PACK N.A.		FROM TO FT.		LOGGED BY T.C. MORIN			
SEAL BENTONITE CHIPS		FROM 2.0 TO 33.5 FT.		SAMPLING METHODS		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING	
GROUT CONCRETE		FROM 0.0 TO 2.0 FT.		2.5" SPLIT SPOON		<input type="checkbox"/> STAND PIPE _____ FT.	

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/8 IN)						
								WELL-GRADED SAND WITH SILT AND GRAVEL; brown, damp, loose; 70% medium sand, 15% gravel, 15% silt; tank excavation backfill material
O	0.1	21 32 54					SW/SM	
U	1.6	4 21 36 41	20	B-3-18.5				
U	1.7	15 21 29 42	25	B-3-22.0			SP	
U	1.7	25 17 8 5	30	B-3-27.0				POORLY GRADED SAND; greenish gray, moist, dense; 80% medium sand, 10% gravel, 10% silt; rock lodged in sampler at 17'-no recovery, resampled at 18.5'; strong hydrocarbon odor

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION PIONEER BUILDERS SUPPLY				Boring/Well Name B-4	
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		DRILLER GLENN BOUGE		Project Name STF PH 1 SOIL-PIONEER	
DRILLING METHOD HOLLOW STEM AUGER		DRILL BIT(S) SIZE: 6 5/8" I.D.		Project Number 916055.07	
ISOLATION CASING N.A.		FROM TO FT.		ELEVATION AND DATUM	
BLANK CASING N.A.		FROM TO FT.		TOTAL DEPTH 30.0	
PERFORATED CASING N.A.		FROM TO FT.		DATE STARTED 05/14/1991	
SIZE AND TYPE OF FILTER PACK N.A.		FROM TO FT.		DATE COMPLETED 05/14/1991	
SEAL BENTONITE CHIPS		FROM 2.0 TO 30.0 FT.		INITIAL WATER DEPTH (FT)	
GROUT CONCRETE		FROM 0.0 TO 2.0 FT.		LOGGED BY T.C. MORIN	
				SAMPLING METHODS 2.5" SPLIT SPOON	
				<input type="checkbox"/> WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input type="checkbox"/> STAND PIPE _____ FT.	

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL NOT CONSTRUCTED	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/8 IN.)						
U	1.8	4 2 7 5		B-4-0.5			OH	ORGANIC SILT WITH SAND; black, moist, loose; topsoil
U	1.7	8 10 12 14	5	B-4-3.0			GP	POORLY GRADED GRAVEL; brown, damp, dense; 85% medium to fine gravel, 15% medium sand, trace silt
U	1.7	37 28 27 21	10	B-4-8.0				POORLY GRADED SAND; reddish grey, moist, dense; mostly fine to medium sand, some gravel; gravels decrease with depth as sand coarsens
U	1.6	21 19 15 12	15	B-4-13.0				
U	1.4	58 50 48	20	B-4-18.0			SP	
U	1.7	32 28 32 40	25	B-4-23.0				sand fraction fines (~80% fine to medium sand); strong odor and possible discoloration at 25'
U	1.8	38 24 23 39	30	B-4-28.0				

Boring & Well Construction Log

Kennedy/Jenks Consultants

BORING LOCATION PIONEER BUILDERS SUPPLY				Boring/Well Name NMW-1A			
DRILLING COMPANY LAYNE ENVIRONMENTAL SERVICES		DRILLER DEAN KOONTZ		Project Name STF PH 1 SOIL-PIONEER			
DRILLING METHOD HOLLOW-STEM AUGER		DRILL BIT(S) SIZE: 10" O.D.		Project Number 916055.08			
ISOLATION CASING NONE		FROM TO FT.		ELEVATION AND DATUM 252.0 FT MSL		TOTAL DEPTH 48.5 FT	
BLANK CASING 4" SCHEDULE 40 PVC		FROM -2.0 TO 21.0 FT.		DATE STARTED 03/05/1991		DATE COMPLETED 03/06/1991	
PERFORATED CASING 4" 0.020"-SLOT SCHEDULE 40 PVC		FROM 21.0 TO 46.0 FT.		INITIAL WATER DEPTH (FT) 31.0			
SIZE AND TYPE OF FILTER PACK 10-20 COLORADO SILICA SAND		FROM 18.0 TO 48.0 FT.		LOGGED BY T.C. MORIN			
SEAL 1/4" BENTONITE PELLETS		FROM 15.0 TO 18.0 FT.		SAMPLING METHODS 2.5" SPLIT SPOON		WELL COMPLETION <input type="checkbox"/> SURFACE HOUSING <input checked="" type="checkbox"/> STAND PIPE 2.0 FT.	
GROUT CEMENT/BENTONITE MIX		FROM 2.0 TO 15.0 FT.					

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLDG/8 IN.)							
			5						POORLY GRADED SAND WITH SILT AND GRAVEL Tannish gray, moist. (tank excavation backfill material) Changes in drilling pressure indicate presence of debris or large cobbles.
			10						
			15						
			20						
U	1.2	3 3 5		NMW-1A-18.5		850			POORLY GRADED SAND Greenish gray, wet, loose, 85% medium sand, 10% fine sand, 5% fines. Probably discolored, strong hydrocarbon odor. Discoloration lessens. Moist, no free water.
U	1.5	16 34 37		NMW-1A-23.5		250			
O	1.7			NMW-1A-25.5					
U	1.0	27 50		NMW-1A-28.5		>1000			
			30						

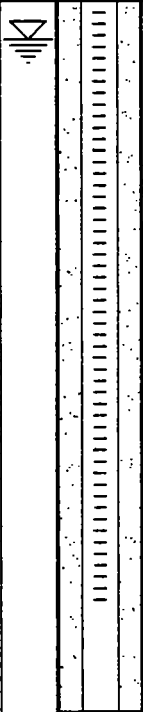

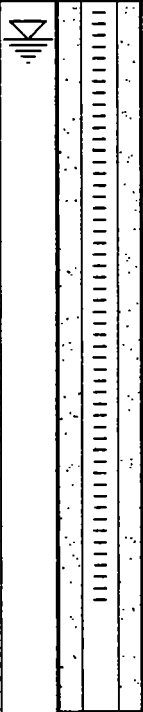

Boring & Well Construction Log

Kennedy/Jenks Consultants

Project Name SOUTH TACOMA FIELD

Project Number 916055.08

Boring/Well Name NMW-1A

SAMPLES			DEPTH (FEET)	SAMPLE NO.	WELL CONSTRUCTION	OVA (ppm)	LITHOLOGY	USCS LOG	SAMPLE DESCRIPTION AND DRILLING REMARKS
TYPE	RECOVERY (FEET)	PENETRATION RESIST (BLOWS/IN)							
								SP	Continued strong odor.
U	1.3	17 32 42		NMW-1A-33.5		>1000			
			35						
U	1.2	3 6 7		NMW-1A-38.5		>1000			Increasing coarse sand. Few to little fine gravels present.
O	2.0		40	NMW-1A-41.0		870			Occasional cobbles.
G	0.2	20 50/3		NMW-1A-43.5		960		SP	
			45						
G	1.3	20 34 26		NMW-1A-47.5		>1000			Heave in borehole.